JOURNAL
OF THE
AMERICAN WATER WORKS ASSOCIATION

VOL. 28 DECEMBER, 1936 No. 12

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SECRETARY'S OFFICE, 29 WEST 39TH STREET, NEW YORK

All correspondence relating to the publication of papers should be addressed to the editor, Abel Wolman, 2411 North Charles Street, Baltimore, Maryland.

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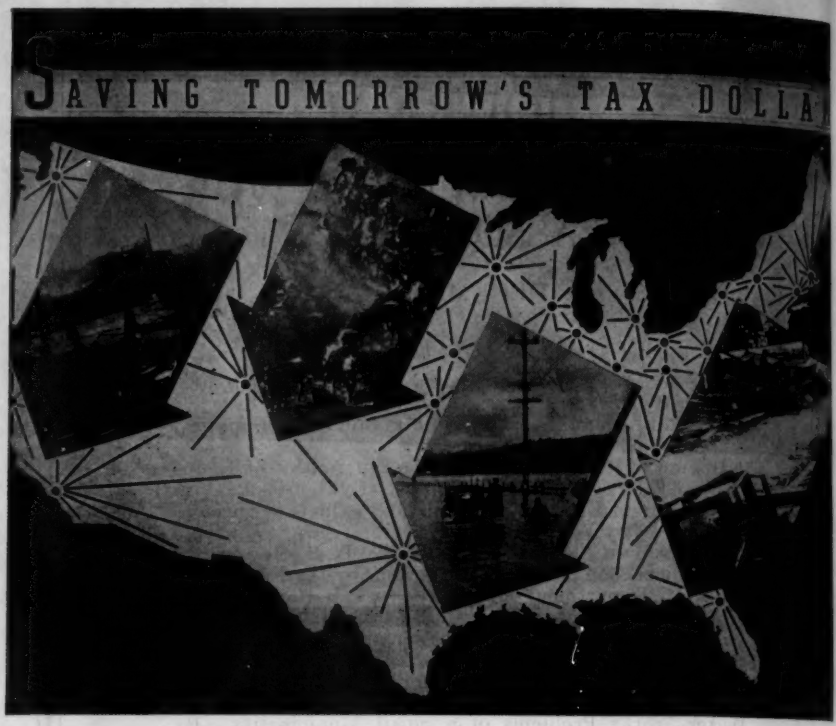
Subscription Price, $7.00 per annum



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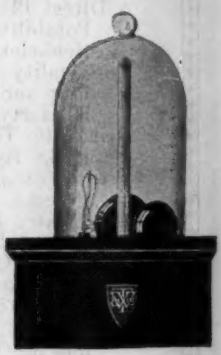

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Vol. 28 DECEMBER, 1936 No. 12

THE 1936 FLOOD AND PENNSYLVANIA PUBLIC WATER SUPPLIES

By H. E. Moses

(*Assistant Chief Engineer State Department of Health, Harrisburg, Pa.*)

An appropriate text for a subject such as this may be found in Genesis in that thrilling account of the Deluge. In the Seventh Chapter, tenth verse is this terse statement: "And it came to pass after seven days the waters of the flood were upon the earth." No doubt Noah had his water supply troubles in the ark, but at least his establishment was mobile and rode the crest, instead of being placed along a stream which engulfed it in the raging waters, some of the results of which it is the purpose of this Symposium to set forth.

This first flood set an all-time record which, fortunately for the human race, has never been equalled. As Pennsylvanians we are not averse to seeking records, but in the matter of floods we hope that the one attained during March, 1936 will be for all time; we do not covet supremacy of that sort. There were two floods in fact—the Ice Flood of late February, reaching its peak about March 13–14, and followed by the Big Flood of St. Patrick's Day. Since the Ice Flood had little serious effect upon public waterworks in Pennsylvania—Parkers Landing and a few other communities being the exception—this paper will be devoted to a discussion of the Second or St. Patrick's Day flood, so-called because of its relation in time to March 17.

In passing, mention should be made that had not the tremendous burden of ice, between 22 and 36 inches thick, with which the main rivers were locked, largely passed downstream on the crest of the earlier flood, the combined effect of heavy ice and the excessive run-off of the second flood probably would have increased the disastrous results of the St. Patrick's Day flood, which were of themselves sufficiently appalling.

CAUSE

Heavy snowfalls with accumulations of great depth of snow, frozen soil, excessive rain, with temperatures above freezing, all combined to produce a flood without precedent in Pennsylvania. The preceding events, climatologically speaking, are concisely and well set forth in the following Abstract from the March, 1936 Weather Bureau Report—Pennsylvania Section:

"March temperatures were mostly above the normal, with greatest departures in the eastern half of the State. March has had higher averages for Pennsylvania seven times in the last 49 years, the warmest being in 1903, with an excess of 8.7 degrees as compared with 4.9 degrees this year. The precipitation was the greatest of record for March. The snowfall was heavy in the northern tier of counties, and in all of the Ohio drainage area. It had been heavy during the first half of February, and, with low temperatures during the last half of the month, a large part of the snow cover remained on the ground at the beginning of March. The snow had melted within itself to a considerable extent, and its water content was large. This was supplemented by from two to four inches of new snow in the greater portion of the State on March 2nd and 3rd. As a result the heavy rains and melting snows of the 11th and 12th caused serious floods in all of the streams of the State, in some places exceeding all previous gage records. These flood waters had only partly subsided, leaving some snow cover on the upper watersheds, with considerable frost in the ground, when excessive rains of the 17th to 19th, inclusive, brought the streams to much higher stages than occurred with the first rise. At nearly all river stations the gage readings were the highest of record, and at most places in the Susquehanna and Ohio drainage area they exceeded the high water marks of all time."

SCOPE

A glance at the river system of Pennsylvania will indicate how well set we were to realize to the full the effect of the vast volumes of water racing down to the sea. Along the eastern border flows the Delaware River with a watershed above Philadelphia of 10,002 square miles. Next westwardly lies the Susquehanna draining two-thirds of the State, its headwaters reaching north into New York and to the

west finding its origin on the eastern slopes of the Alleghenies, with a catchment area above Harrisburg of almost 25,000 square miles. West of the mountains lies the gathering ground of the Ohio River, reaching into New York with its right branch, the Allegheny, and south into West Virginia with the Monongahela. Below the junction, the Ohio sweeps on into Ohio State, augmented by the Beaver coming from the north. At Pittsburgh the Ohio has an upstream watershed of 19,106 square miles. Combined, these three major streams have a watershed area above Philadelphia, Harrisburg and Pittsburgh, respectively, of 53,200 square miles.

What a gathering ground for the waters which, rushing madly through this populous State, created such wide-spread devastation. And what a tremendous volume of water they carried. The discharge figures are staggering. At maximum gage height the Delaware at Trenton had a discharge of 228,000 c.f.s.; the Susquehanna, 740,000; the Ohio at Sewickley, below Pittsburgh, 574,000. One cannot grasp the magnitude of such figures, but a statement from the Pennsylvania Department of Forests and Waters gives an inkling of what this means:

"Seven hundred and seventy-five thousand cubic feet of water per hour was passing Harrisburg at the highest stage of the Susquehanna River during the recent March flood, the Department of Forests and Waters and the U. S. Geological Survey announced today. This stage was reached March 19, and the record high flow was maintained for three hours, calculations show.

"During this brief period sufficient water was flowing to fill the Commonwealth's huge Pymatuning reservoir in Crawford County, which is 25.7 square miles. Its water capacity is 64,275,000,000 gallons."

Governor George H. Earle of Pennsylvania gave an accurate picture of the situation in his speech to the Red Cross in Chicago in May. In part he said:

"On March 17, flood waters roared through the city of Johnstown. At the same hour they were flooding the lowland areas of Wilkes-Barre, the heart of Pennsylvania's great anthracite region. Before the next morning they were striking at Pittsburgh's Golden Triangle, the center of business life in our second largest metropolis.

"By evening of the following day a hundred Pennsylvania communities, in eighteen of Pennsylvania's sixty-seven counties, were stricken by flood. Those counties covered an area of 12,732 square miles, with a population of four million people.

"The affected area was larger than the entire State of Maryland. It was substantially larger than Massachusetts. It was larger by 4000 square miles

than the combined areas of Connecticut, Delaware, Rhode Island and the District of Columbia.

"Our most authentic reports show that seventy-two persons were killed and 2822 injured; 50,739 left homeless. There were 1078 homes and 1776 other buildings totally destroyed, 42,996 homes and 37,185 other buildings badly damaged. A total of 61,996 persons lost furniture and household goods. At the height of the floods our various disaster relief agencies were housing 89,620 persons, and feeding 159,893."

FLOOD HEIGHTS

As stated above, new flood height records were reached at most of the gaging stations. In table 1 data are shown as to flood heights at certain key stations in the Susquehanna and Ohio basins. The Dela-

TABLE 1

Some maximum gage heights in Susquehanna and Ohio River Basins

DRAINAGE BASIN	RIVER	POINT OF MEASUREMENT	MAXIMUM 1936 FLOOD	TIME		MAXIMUM PREVIOUSLY RECORDED	DIFFERENCE
				March	Hour		
			feet				*feet*
Susquehanna	West Branch	Williamsport	33.57	18	9 p.m.	32.4	1.17+
	North Branch	Wilkes-Barre	33.07	20	2 a.m.	33.1	0.03−
	Susquehanna	Sunbury	26.85	19	2 p.m.	22.5	4.35+
	Juniata	Newport	34.24	19	7 a.m.	35.9	1.66−
	Susquehanna	Harrisburg	30.33	19	6 p.m.	26.8	3.53+
Ohio	Stony Creek	Johnstown	30.26	18	12:30 a.m.	28.3	1.96+
	Ohio	Pittsburgh	46.0	18	9 p.m.	39.9	6.1+
	Ohio	Sewickley	34.75	18	10 p.m.	28.0	6.75+

ware River is omitted since its flood effect on public waterworks was negligible. These show by comparison the maximum gage heights previously recorded. It will be noted that at only two places, Wilkes-Barre and Newport, were former heights not topped.

LOCATION OF PUBLIC WATER WORKS

Delaware River Basin

While high water occurred in the Delaware River Basin, its effect on public waterworks in that area was light as compared with the

Susquehanna and Ohio Basins. On the Delaware itself only two waterworks were seriously disturbed. At Yardley, population 1300, the plant was shut down temporarily while at Morrisville, population 5400, the filtration plant continued operation under difficulties. Fortunately no trouble occurred on the Schuylkill, a river which has always been dangerous during flood periods to the water filtration plants along its banks. These plants comprise three in Philadelphia and five others in a 25 miles stretch above the city, and serve 1,160,200 consumers.

Susquehanna Basin

The plants on the Susquehanna did not fare so well. However, in relation to its size and area drained, this major river itself is little used for public supplies. The Pennsylvania-Maryland state line is 15 miles above Chesapeake Bay, and from here upstream to Harrisburg, inclusive, a stretch of 55 miles, the river is used by only five communities, comprising two power developments, population 525, Columbia and Steelton boroughs, population 25,000, and City of Harrisburg, 80,000 population.

Thence upstream no use is made of the main river for 55 miles where, at Sunbury, it is an auxiliary supply, and, although the river station was flooded, a continuous supply was furnished the town from a tributary stream, the regular source. Between Sunbury and Wilkes-Barre—60 miles—three places use the river—Danville, 7,100 population; Danville State Hospital, 1,900 population; and Berwick, 12,600 population. From here to the New York line—75 miles—Sayre, 7,900 population, is the only place drawing from the river.

The use of the North Branch is even less. The little town of Lumber City, 265 population, and Muncy, 2,400 population, for an emergency supply, comprise this list. Newport, 1,900 population, alone uses the Juniata River, and this as an auxiliary supply.

In addition to the main river plants, quite a number of waterworks on tributary streams were rendered inoperative or were seriously interfered with. Nevertheless, a bright side of the picture is the fact that in several of the largest population centers of this basin upland supplies, unaffected by the raging torrents in the valleys, continued an ample supply of water of good quality to their stricken communities on the lower levels. Altoona, 82,000 population, Williamsport, 46,000 population, and the Wilkes-Barre-Scranton District, 700,000 population, are notable examples of this situation. A fortunate circumstance undoubtedly affecting the health record.

If the Johnstown District, 80,000 population, in the Ohio River Basin, which suffered terrible loss, had any alleviating factor in an otherwise drab situation, it was the continued service of ample water of safe quality from the storage reservoirs in the mountains high above the valley torrents.

Ohio River Basin

But when we consider the Ohio and its tributaries, a different picture emerges. In this area, more than in any other part of Pennsylvania, greater use is made of the valley streams; the main river and its principal branches and their important tributaries. The Allegheny, for 35 miles above Pittsburgh, to Kittanning, the Monongahela from Pittsburgh to the West Virginia line 60 miles south, the Youghiogheny as far upstream as Connellsville, the Beaver and the Shenango all the way north to Sharon and the Ohio itself below Pittsburgh—direct at Midland and through wells and cribs otherwise—constitute a vast reservoir drawn upon to supply this principality, with its teeming millions, occupying the southwestern corner of Pennsylvania. It is obvious that disturbance of waterworks in this area would affect more consumers than in any other part of the Commonwealth except Philadelphia and proportionately increase the health hazard.

The far-reaching effect may be appreciated when it is remembered that of a total of 106 waterworks in Pennsylvania, affected by the St. Patrick's Day flood, 66 are in the Ohio River Basin, including that of the City of Pittsburgh which alone serves 600,000 consumers. These 66 waterworks in the aggregate supply 1,567,190. What a chance for typhoid-laden water to wreak appalling damage. Fortunately, it did not.

EFFECT ON WATER WORKS

Did time permit it would be possible to relate 100 stories of as many waterworks, to tell of the rise of the streams rapidly approaching the danger line; of the frequently revised forecasts of higher flood heights which took away finally the lingering hope that one's plant might escape; the efforts made to build up reserve storage to carry over the period of shut-down; the erection of emergency barriers to exclude the flood waters from the plants to the last possible moment; precautionary measures for the protection of machinery; warning to

consumers; and the final withdrawal after all efforts failed, leaving the plant to the mercy of the inundating waters.

Then followed a varying period of inaction as to actual operation, but by no means one of inactivity, for plans must be laid for resumption of service at the earliest possible moment, accomplished only after exhausting efforts and sleepless hours; and, finally, the seemingly impossible attained and water—safe water—again flowing into homes where its use was so greatly needed and of whose value the user now had a better conception because of its scarcity during the hours of flood.

One thing most plants had in common—muck and silt—in basins, on filters, plastered on walls and spread on floors, in machinery and over apparatus. Coal was washed away or into the plant; piping was disarranged and intricate equipment either destroyed or badly

TABLE 2

Part of plant affected

PART AFFECTED	NUMBER OF PLANTS
Pumps	61
Chlorination apparatus	35
Filters	13
Clear well	23
Chemical feed apparatus	13

crippled. Out in the system mains were broken, valves damaged, hydrants upset and service pipes snapped off, causing heavy leakage until corrected. At stream crossings pipe lines were swept away or broken by bridge failure. At some plants electric current failed, necessitating complete shut-down.

Yet despite these almost impossible handicaps, service of some sort, greatly curtailed perhaps, was maintained in nearly every part of Pennsylvania and, after the flood waters subsided, regular service was resumed in remarkably short order. A notable achievement.

Approximately 100 public waterworks—106 to be exact—were affected by this flood. These waterworks serve 1,909,870 consumers. Pumps were the worst sufferers—61 plants. Thirty-five plants had chlorination apparatus disturbed. Filters in 13 plants were flooded and 23 had flood water in the clear well, while chemical feed apparatus was affected at 13 plants. Some, of course, had all these things

happen, while others had one or more of them. Of the 106 affected, 72 were obliged to discontinue operation and 34 continued in service, haltingly perhaps, but still alive. Meanwhile, consumers were supplied from storage, adjoining systems, and by tank trucks—any practical way to maintain at least partial service. These data are summarized in table 2.

HEALTH MEASURES

Intimately related to the story of Pennsylvania's Public Water Supplies is that of the Department of Health in its effort to protect the public health. Too long to be told here and deserving of separate narration, it should be noted that before the Ice Flood the Bureau of Engineering prepared a plan approved by Dr. Edith MacBride-Dexter, Secretary of Health, for protection of public and private water supplies menaced by floods. District Engineers kept close check on plants menaced by floods in the past, notifying such water-works to be prepared for eventualities; the engineers were ready to assist any plants in difficulty; Department and municipal health authorities were advised as to procedure for safeguarding flooded private supplies and as to sanitation measures in flooded areas; arrangements were made for securing immediate information as to ice jams and river stages and its transmittal to interested persons; motorized water tanks were arranged for to haul water into affected district; and the Department's motorized laboratories were made ready for instant service if needed. Works Progress Administration promised to furnish labor for clean-up.

This furnished the nucleus of a plan greatly enlarged when the St. Patrick's Day flood occurred. The Bureau's field force was greatly augmented, reaching a total of 280, comprising engineers, chemists, bacteriologists, flood survey workers, stenographers, clerks and health officers, stationed at Harrisburg and at strategic points throughout the flood districts. Through the coöperation of the U. S. Public Health Service, ten engineers were made immediately available and were of invaluable assistance. Three motorized laboratories were stationed at Wilkes-Barre, Johnstown and Greensburg respectively, and examined about 10,000 samples of public and private supplies; with another 2,000 in our Philadelphia Laboratory, the equivalent of a year's normal sampling.

The public was warned by radio, newspapers, placards and by word of mouth of the danger of using impure water, and advised of safety

measures. Tanks were sent into sections without water, filled with supplies secured from safe sources. Our engineers inspected plants and conferred with waterworks officials as to means of meeting the innumerable contingencies arising. Sanitation measures in clean-up problems, involving thousands of persons, had to be devised and executed. Tons of lime and chloride of lime were distributed in the flooded areas.

THE RESULTS

And so one might, like the famed brook, go on and on in a recital of the battle waged ceaselessly for days in the interest of the health and welfare of Pennsylvania's citizens, but neither time nor your patience will permit. Just a word as to results from the standpoint of disease. An abstract from a statement made May 12, 1936 by Dr. J. Moore Campbell, Director, Bureau of Health Conservation, Pennsylvania Department of Health, well sets forth the situation:

"Complying with your request of the other day for information concerning intestinal infections or others resultant from our mid-March flood experience, it is a matter of considerable satisfaction to be able to say that these have been far fewer than we probably had any right to really expect and are, indeed, essentially negligible.

"In view of the large areas inundated and the populations, urban as well as rural, involved it is a little short of miraculous, perhaps, that we have had only four cases of typhoid fever which can be definitely related to flood-borne infection. All of these have been reported from the City of Pittsburgh. Neither was there at any time any occurrence of diarrheal disease in any inundated district. Upper respiratory infections were reported in some numbers from Wilkes-Barre and neighborhood and also from Johnstown but there was no unusual prevalence of pneumonias. Meningitis, which might also have been expected, especially among refugees temporarily quartered and no doubt crowded as at Johnstown, Wilkes-Barre and those from Sunbury at Shamokin, did not make its appearance. On the whole, therefore, the absence of epidemic illness has been one of the striking features of the disaster.

"A satisfactory explanation of our escape may not be altogether easy. It so happened that with respect to many of the good-sized towns and cities the floods found water works on heights beyond reach, so that safe water supplies were continuous. In some where reservoirs at least were beyond flood waters forethought on the part of our Engineering Bureau and water works operators, even as early as the breaking up of ice and the formation of gorges were foreseen, had prompted the storage of maximum supplies. These, in some instances, were sufficient to tide over the community until filter beds, pumping stations, etc., could be cleansed and repaired. The hauling of safe water in motor tanks when it could not otherwise be provided was also a factor. So, too, no doubt was a relatively rapid clean-up of débris and muck made possible

through the availability of W. P. A. labor, duration of exposure to possibly contaminated river and creek deposits being thus reduced to a minimum period."

LESSONS LEARNED

Some conclusions may be drawn from this experience; outstanding perhaps was the incalculable value of ample storage. This was the salvation of many communities. When the production end of the waterworks was shut down citizens were supplied with water from that in storage both for domestic purposes and for the tremendous task following of sanitary clean-up.

Upland supplies need no argument to convince of their desirability. At any time they are usually of better quality than the water in the valley streams. In this time of flood communities which had upland supplies were indeed fortunate in that their service was practically uninterrupted. Consideration might well be given to the possibility of substituting an upland supply for one taken from a valley stream.

If there was ever any doubt as to the value of chlorine in connection with public water supplies, that doubt is effectively removed by the part chlorine played in this flood. In many instances it was the only barrier between an unsafe water supply, which had to be used, and the health of the consumer. Its generous use throughout the flooded district unquestionably had a bearing upon the safety of water served to the public. Consumers drank water carrying a higher residual chlorine than ever before and much higher than is necessary in actual practice, but generally they did not complain and I think in most instances the knowledge that chlorine was in the water was comforting.

Failure of electric current raises the question as to the expediency of having standby units independent of electric motive power. The steam-driven plants probably were restored to service with less trouble than plants electrically equipped where motors were flooded.

Failure of pipe lines at stream crossings showed the need for auxiliary mains. It also developed that the waterworks officials should keep check on the availability of such stream crossings. Several instances occurred where alternate lines were in place but their serviceability had not been checked and when test came they could not be used. Pipe lines at stream crossings should be properly valved so that the flow can be easily and quickly controlled should a break occur. At one such crossing much stored water would have

been saved had there been a valve on the line where it passed under the stream. Valving of the distribution system should be studied with a view to providing facilities for easily controlling the distribution of water. In some cases the pipe line men were hampered considerably because of the lack of sufficient valves.

Thought might be given to the erection of facilities for placing barriers at doors and windows at the river plants which, upon occasion, could be quickly put into service and would be much more effective then the emergency make-shift measures adopted to exclude flood water.

Of course, outweighing all of these features is the broader subject of flood control, in which every waterworks man naturally is interested, and to which movement he should lend his influence and efforts in order that some practicable means of flood control may be devised and put into effect in an effort to prevent a repetition of such disastrous floods.

CONCLUSION

In closing permit me to pay tribute to the zeal and devotion to duty of the waterworks personnel. It was inspiring to witness from personal observation the unselfish efforts of all, from the highest to the most lowly, to meet this desperate emergency. It meant hours of unremitting toil under the most trying and adverse conditions when men's nerves were frayed and bodies exhausted. Despite all this they kept on and thereby enrolled themselves in that great battalion of unsung heroes, of whom the public knows little and to whom usually the only recompense is the personal knowledge of a task well done.

(*Presented before the Central States Section meeting, August 20, 1936.*)

THE 1936 FLOOD AND WEST VIRGINIA PUBLIC WATER SUPPLIES

By E. S. Tisdale

(Director, Division of Sanitary Engineering, State Department of Health, Charleston, W. Va.)

On March 18, 19 and 20, 1936, a flood in the upper Ohio River, exceeding all previous records, carried out the predictions which the late Morris Knowles made some ten years ago when, as a leader in the Pittsburgh flood control program, he urged action after comprehensive rainfall and watershed studies had been completed. At that time he said:

> "Pittsburgh's flood of March 15, 1907, will dwindle into insignificance in height, extent, devastation and damage when an Ohio rainfall of an intensity such as caused the Miami flood travels across the watersheds of the Monongahela and Allegheny Rivers. This may be anticipated and when it happens we will have a flood in Pittsburgh of at least 45 feet. The entire business section will be flooded up to Smithfield Street and all trade and transportation will be at a standstill. When this happens the damage, not only because of higher waters, but also because of the greater development of the territory, will be far beyond anything yet experienced or even approached."

Almost thirty years later Mr. Knowles prophesy came true and this flood swept down two rivers, the Potomac and the Ohio in West Virginia. It will not be possible in this brief paper to outline chronologically what happened in each community from the standpoint of water supply as the flood waters swept through it. A brief summary will be set forth, which shows the location of the city on the respective watershed, the source of the public water supply, the purification equipment available, and also the emergency steps taken to safeguard the drinking water supply.

INTERSTATE AND FEDERAL RELATIONSHIP

In this flood of unprecedented proportions it is interesting to note how the interstate and federal relationships worked out to keep drinking water safe when sudden emergencies arose.

At Williamstown, a short distance above Parkersburg, Marietta,

TABLE 1

Public water supplies affected by flood—Ohio River territory

CITY	DISTANCE FROM PITTSBURGH, MILES	SOURCE OF SUPPLY AND PURIFICATION EQUIPMENT	PROTECTION MEASURES ADOPTED
Chester	43	Deep well—no chlorination	Heavy hypo dosage continued until permanent chlorinator installed
Newell	45	Well and crib in Ohio. Chlorination	Raised rate of chlorination
New Cumberland	57	Springs and well on high ground—not flooded. Chlorination	Heavy chlorination after mains washed away draining reservoir
Weirton	62	Ohio River—Filtration plant	Chlorination increased, after wall around clear well barricaded to keep out flood waters
Follansbee	71	Deep wells—no chlorination. Not affected	None
Wellsburg	65	Deep wells. Water softening plant, filters and chlorination	Very high chlorination causing strong taste after plant and mains flooded
Wheeling	90	Ohio River—20 m.g.d. Filtration plant	Chlorination at 5 times normal rate. Filtration plant operated to capacity during flood
Moundsville	102	Deep wells—not flooded	Chlorination increased
New Martinsville	128	Dug well—no protection	Well flooded by river water. State emergency chlorinator installed
Sistersville	137	Ohio River—Filtration plant	Raised chlorination. Pump station flooded
Paden City	133	Deep wells on high ground	None
St. Marys	155	Deep wells on high ground	None
Williamstown	172	Marietta, Ohio, wells and river water filtration and chlorination	Shift to well water. High chlorination of river water

TABLE 1—*Concluded*

CITY	DISTANCE FROM PITTSBURGH, MILES	SOURCE OF SUPPLY AND PURIFICATION EQUIPMENT	PROTECTION MEASURES ADOPTED
Parkersburg	184	Wells along river bottom. Chlorination. Flooded and system temporarily abandoned, using filter beds in Ohio River	Very high chlorination when well water became muddy
Point Pleasant	265	Deep wells. No treatment works	State emergency chlorinator installed
Huntington	308	Ohio River filtration plant not affected	Chlorination raised
Kenova	316	Big Sandy filtration plant at Catlettsburg, Kentucky, not flooded	Chlorination raised
Ceredo	315	Big Sandy filtration plant at Catlettsburg, Kentucky, not flooded	Chlorination raised

Ohio furnished a continuously safe water from Ohio into West Virginia. Farther down stream, Huntington, West Virginia, with the filtration plant on high ground, furnished a safe water to Chesapeake, Ohio, across the river. State Health Department engineers kept one another informed on conditions. Still farther down the Ohio, Ceredo and Kenova, West Virginia, were furnished a safe water from Catlettsburg, Kentucky. Telephone communication kept the main office of the State Health Department informed on the river stage and residual chlorine in city water in the Kentucky city. At Ridgeley, West Virginia, on the Potomac River, an impounded water supply from Pennsylvania is piped to Cumberland, Maryland, and thence under the Potomac River to Ridgeley. The Cumberland, Maryland, superintendent of filtration kept our department informed on water conditions and safe water came into Ridgeley at all times. Thus Ohio, Kentucky, Pennsylvania and Maryland state and city authorities were a factor in holding city water supplies safe along the flooded river valleys.

The United States Public Health Service rendered a distinct and valuable service to West Virginia by sending three of their experienced sanitary engineers into the flood areas, H. R. Crohurst, E. C. Sullivan and F. J. Moss, after State Health Commissioner, Doctor A. E.

McClue had accepted the kind offer of assistance from the Public Health Service.

The State Health Department of North Carolina and also the City of Cleveland, through Frank O. Wallene, Director of Public Utilities, kindly offered equipment and personnel to meet the flood emergency.

TABLE 2

Public water supplies affected by flood—Potomac River area

CITY	SOURCE OF SUPPLY AND PURIFICATION EQUIPMENT	PROTECTIVE MEASURES
Piedmont	Savage River Dam—Filtration plant	Mountain gravity water line washed out. Filtration plant at Luke, Maryland, furnished water until repairs were completed
Keyser	Impounded mountain water became muddy. Chlorination	Chlorination increased and filter plant made ready for emergency service
Petersburg	Infiltration crib. Chlorination	Rate of chlorination increased
Moorefield	Dug well—chlorination	Heavy chlorination and flushing mains after river water discharged from flooded water system
Romney	South Branch, Potomac River. Filtration plant	Raised chlorination
Berkeley Springs	Springs. Chlorination	Badly flooded. High rate of chlorination maintained after clean-out of flood water
Shepherdstown	Potomac River. Filtration	Storage sufficient to carry over until flood waters receded from plant and equipment
Martinsburg	Springs. Chlorination	Heavy chlorination after springs were flooded

Mr. H. R. Crohurst reported to Wheeling in Ohio Valley at the peak of the flood, aiding not only the water plant superintendent, but also assisting Doctor Reece Pedicord, City-County Health Commissioner, in planning and executing the important flood clean-up program.

Mr. E. C. Sullivan, after reporting to city-county health authorities at Parkersburg, immediately gave his personal attention to safeguarding the city water supply which had become muddy. Parkers-

burg was isolated by flood waters shortly after his arrival and the state sanitary engineers could not get in until flood waters subsided. This city had no trained sanitary engineer with ability to deal with the water problem. Mr. Sullivan found that the chlorination rate had been doubled by the pump station superintendent as soon as well water became muddy, from 8 to 16 pounds daily for treatment of two million gallons of water. Chlorine residuals and bacteriological tests over the system were taken and chlorine dosage raised to 21 pounds daily. Then the old filtration plant in the bed of the Ohio River was placed in operation by the experienced water works man and the water in the mains began to clear. The wells were still out of service when Mr. Sullivan left several days later.

Mr. F. J. Moss was dispatched from the Washington office of the U. S. Public Health Service to Harpers Ferry on the Potomac River. The havoc wrought along the Potomac Valley was so great, all bridges gone, that Sanitary Engineer Moss took up his station at Charles Town, out of the flood area, but located so that he could best serve the eastern panhandle area. His services were invaluable in adjusting chlorine dosage on flooded water supplies and training field crews of the Works Progress Administration, who worked at the job of properly cleaning and disinfecting private wells in the flooded area after the flood waters receded.

EXPERIENCES AT WHEELING FILTRATION PLANT

The report which A. R. Todd, superintendent of filtration at Wheeling, submitted to the State Health Department tells briefly of his experiences at the plant during the flood period. He speaks of certain precautions which may be worthy of consideration by water works men. It does not appear that the flood control program on the Ohio will be completed for some time, although the Tygart Valley Dam at Grafton will be finished next year.

Mr. Todd reports that at Wheeling, which has a modern water filtration plant of 20 m.g.d. capacity, the sewers had been plugged two days before the crest was expected. However, due to the great pressure these plugs would not hold and it was necessary to have a fire engine on duty to keep the basement pumped out and prevent flooding electrical equipment. The filters were all washed and they thought they were ready for the emergency, but Wheeling had never experienced anything like this flood before. Turbidity was 1350 and this was handled readily with the plant at capacity. The most

unusual thing noted perhaps was the exceptionally high chlorine demand of the filtered water. The chlorine disinfection equipment was stepped up to capacity, 200 pounds per 24 hours or 10 pounds per million gallons, the chlorine demand on filtered water going up from 2½ to 10 pounds per million gallons. However, it was possible to hold a good residual chlorine in the filtered water at all times. Chlorine tests were run every fifteen minutes and bacteriological samples taken every hour. The city water supply showed safe at all times.

Mr. Todd gives the following four suggestions for future guidance in his report to the State Department of Health:

"First, a normal month's supply of the essentials like lime, chlorine and iron sulphate is not enough. We used more iron sulphate in five days than we ordinarily use in thirty days and had to borrow a truck load from our good friends in Washington, Pennsylvania. Fortunately we had ten 150 pound cylinders of chlorine and a reserve of eight 100 pound cylinders. A carload of lime which was on the way has not been located yet.

The second lesson is that some provisions should be made to house the employees at the plant during such emergencies. Only about one-half the the crew was able to get to work and those that got here were on the job from forty-eight to fifty hours.

"The third lesson is that perhaps a third chlorinator for a plant of this size should be kept on hand.

"And the fourth lesson, and they had the same experience in Wellsburg, Martins Ferry, and Bellaire, if you tell the people not to draw water or even mention the water works, they will start filling bath tubs, buckets and even garbage cans with water, causing a further drain on your supply. At such a time many rumors are afloat about your plant and we had to repeatedly announce over the radio that the water was safe and pure and that the plant would not be shut down."

PARKERSBURG'S FLOOD EXPERIENCE

Parkersburg lies at the junction of the Little Kanawha River with the Ohio. The banks are low and the large flat plain here became flooded. Its success in holding a safe city water supply throughout the flood emergency was due to the Civil Service requirement, which has kept the pump station and plant in charge of a competent, reliable superintendent for over twenty-five years.

Mr. Burke in his period of service at Parkersburg has seen the tides of propaganda for either a well water system or a rapid sand filtration plant sweep over the city many times. In 1911, this resulted in a compromise system for developing water—namely, filter

beds in the Ohio River, which obtained ground water like wells, and also filtered river water, like a filtration plant. These filter beds functioned for a few years, became unsatisfactory, and then the water campaign came up again. In 1925, the well water folks won out in a water works contest. A series of wells were installed in the gravel beds along the river, concrete walls being carried up above the 1913 flood level for the purpose of preventing river water from contaminating the wells. The test came with this 1936 flood and the wells "could not take it." On Friday, March 20, muddy water from the wells began to enter the water system. Two of the wells sunk and tilted, breaking the discharge line and placing all the wells along the river bank out of commission. The reservoir supply held the town for about one day and then, on Saturday, March 21, Superintendent Burke started up the old filter beds beneath the Ohio River after moving the chlorinator into the old plant. This water was clear and with heavy chlorination the water from these beds was continued in use for a period of ten days, from March 21 to April 1. After that the muddy water was pumped from the wells and they were again placed in service.

Thus high chlorine dosage—it was raised from 8 to 21 pounds—in disinfecting 2,000,000 gallons per day—the old filter beds below the Ohio River bed and perhaps most important of all, the trained and dependable superintendent on the job who knew what to do in the emergency, saved the day at Parkersburg. He was protected by the state's water works operators licensing system and by Parkersburg's Civil Service requirements.

EMERGENCY PROTECTION OF GROUND WATER SUPPLIES IN SMALL CITIES

Chlorination of all ground water supplies is required as a policy of the State Health Department after the best possible protection has been secured by proper construction to exclude surface water. However, not all the well water supplies in the Ohio and Potomac Valleys were protected by chlorine disinfection. Many of them are located in old communities which flourished in the "steamboat days" before there was any State Health Department. In all new installations like those fifty or more public water supply improvements constructed in the last three years under the Public Works Administration, chlorination has been installed on well water supplies routinely.

New Martinsville and Point Pleasant are examples of two small cities using ground water supplies without chlorine disinfection. It

was necessary to install state-owned chlorinator equipment in these two communities during the flood emergency. New Martinsville is situated on low lying ground at the mouth of Fishing Creek and the flood waters which were 12 feet deep through the main street of the city began to seep into the large dug well furnishing the water supply. Then the water superintendent called the State Health Department for help, but it was too late for the sanitary engineers to reach him with emergency equipment. The railroads and highways to Charleston were cut off by high water. Those leading to Sistersville and Moundsville, upstream, were open, lying on high ground, and the state engineers by telephone secured the coöperation of these privately and publicly owned water works to obtain emergency chlorinating equipment and have it installed at New Martinsville. The city has since purchased and installed their own chlorinating apparatus, but it took a real flood demonstration to put the project through.

Point Pleasant is another city which desired protection of the drinking water supply and it is well they called for help, for the flood waters remained in this city for practically two weeks due to the subsequent rains and later floods on the Great Kanawha River. It was necessary for the sanitary engineer taking emergency chlorinating equipment to use train, boat and auto to reach this small city at the mouth of the Kanawha. All night long after the installation was completed, along the main street of the town, the rowboats, lanterns in the bow, were passing just under the bedroom windows of the hotel and those high waters remained for nearly fourteen days.

WORTH OF STATE TRAINING SCHOOLS AND LICENSING PLAN TESTED

West Virginia has followed out the admirable plan which Ohio started some fifteen years ago of bringing the water works men together for annual conferences. This is for the purpose of getting acquainted one with the other and learning from people with wider experience.

In West Virginia, the State University engineering school and the Sanitary Engineering Division of the State Department of Health have teamed up in running the school and it has been the means of training the older water men and bringing the graduates of the University into the water works field. For ten years the educational program has gone on and in 1932, a licensing regulation was passed by the Public Health Council of the state, written examinations were held, and the water works men and filtration plant super-

intendents and operators in charge of chlorinators were licensed by the State Health Department, in Class I, Class II and Class III designations.

If you visit any water works in West Virginia, be it large or small, you will find that certificate framed and hanging on the wall as an evidence that the man has been examined in the science of water purification and he has proven his fitness for this important position with respect to the community's health.

It was this group of men, who were in charge at large and small water works in the Ohio River and Potomac River valleys, who proved of the utmost worth in meeting the flood emergency. They were put to the test and came through with flying colors. They acted with good judgment in holding public water supplies safe.

PREPARATIONS TO MEET FUTURE FLOOD EMERGENCIES

1. The state, city or county sanitary engineer is a strong ally for the water works superintendent. In times of emergency as demonstrated in the March, 1936, flood, he promptly acts to safeguard the public water supply. The fact that West Virginia found it necessary to have outside assistance for her towns and cities demonstrates the truth of Charles G. Hyde's assertion that each city and county with a population of 50,000 or more persons should employ a qualified public health engineer. In the sections of West Virginia where such services were available the flood emergency was handled promptly and efficiently.

2. Municipal filtration plants located in areas subject to floods should give consideration to more adequate storage for chemicals. Stocks are depleted at several times the normal rate in flood emergencies. Ample reserve capacity on chlorinator equipment is good insurance toward public health.

3. Civil Service protection for qualified, trained, experienced water works officials should be sought more widely over the country. At Parkersburg, the local Civil Service requirements combined with the State Health Department licensing system for water purification plant operators were effective in holding the city water supply safe in the face of a major emergency. Every practical measure should be adopted to raise the calibre of the men in charge of both large and small water treatment plants to secure prompt and intelligent local action in flood emergencies to safeguard public health.

(Presented before the Central States Section meeting, August 20, 1936.)

A REVIEW OF RECENT PROGRESS IN THE ELIMINATION OF TASTES AND ODORS FROM WATER SUPPLIES

By Charles R. Cox

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The general public has always been quite sensitive to the physical character of water delivered by municipal water supply systems, but a much more critical attitude has developed recently because the widespread delivery of attractive water has resulted in a demand for similar water in all municipalities. Before 1928, however, little attention was given to the elimination of tastes and odors except in the use of copper sulphate for the control of microörganisms. In that year, however, the chlorine-ammonia treatment was introduced into this country from England and great interest was shown in the prevention of chlorinous tastes through the preliminary use of ammonia. Following this activated carbon was introduced in 1931 for the removal of tastes and odors. Concurrently with these developments, the successful treatment of phenolic wastes was developed at by-product coke plants so that streams are now quite generally free from these very objectionable taste producing compounds. As a result of these very important developments, it is now possible to make the optimistic statement that tastes and odors may be completely eliminated from water supplies if funds are available for the construction and proper operation of suitable water purification equipment.

ESTIMATED INTENSITY OF TASTES AND ODORS

The older standard method of estimating the intensity of tastes and odors in samples of water was very crude and was not quantitative in nature. Recently two procedures have been developed for estimating odors which are quite sensitive and also permit assigning a quantitative value to the intensity of odor. A description of these procedures is given in the Eighth Edition of the Standard Method of Water Analysis published this year, in the volume entitled "Elimination of Tastes and Odors in Water," by John R. Baylis, published by the McGraw-Hill Company of New York City, and in the November, 1934 and April, 1936 issues of *The Journal*. Briefly, it may be

stated that one procedure consists in diluting the sample with graded amounts of odor free water until the mixture has a barely perceptible odor when using the so-called osmoscope. This consists of a glass tube shaped so as to fit the nostrils, the other end being inserted into the flask holding the sample. The degree of dilution of the original sample with odor free water is used in computing the intensity of the odor of the sample. The second procedure consists in the use of a special osmoscope, whereby the air above the sample of water being examined, containing the odoriferous compounds, is diluted with outside air until the mixture has a barely perceptible odor, the degree of dilution with outside air being indicated by the calibrations of the equipment, so that the intensity of the odor may be computed.

An osmoscope for use with the water dilution method can be made by heating the end of a glass tube about one-half inch in diameter in the flame of a Bunsen burner so that the glass becomes soft and permits the end of the tube being enlarged so as to cover both nostrils. This tube is inserted in the glass flask containing the sample, which has been well shaken, so that undiluted air containing the volatile odor producing substances originally present in the water may be drawn into the nostrils. The air-dilution type of osmoscope may be purchased from laboratory supply houses.

The significant fact is that this improved odor test places in the hands of water purification plant operators the means of controlling the treatment of water in taste and odor prevention. For instance, experience has shown that if an undiluted sample of water at the room temperature of 20°C. or less has no odor, or that if a sample of water diluted with an equal volume of odor free water and heated to a temperature of 70°C. has a barely perceptible odor when using the osmoscope, such water will be considered as odor free and acceptable to the general public. This indicates, of course, that the final effluents of water purification plants should have a threshold odor value of less than one for cold water and two for hot water when expressed on the odor dilution scale.

Those in charge of public water supply systems should secure an osmoscope for routine use in this manner.

TASTE AND ODOR PRODUCING SUBSTANCES

The sense of smell is much more sensitive than the sense of taste and hence many so-called tastes are in reality odors. It is not surprising, therefore, that many of the substances imparting tastes and

odors to water are volatile in nature and that they may be eliminated by aeration. This is especially the case with the essential oils liberated by living microscopic vegetation. On the other hand, the tastes and odors imparted by the decay of vegetation are more difficult to eliminate. It is essential, therefore, that every effort be made to prevent the entrance of swamp drainage into reservoirs and the accumulation of organic matter which later will be subject to decay in reservoirs.

Tastes and odors incidental to the entrance of sewage and industrial wastes into streams cannot be prevented by those in charge of water supplies, but governmental departments are endeavoring in every way possible to prevent the pollution of streams to a degree where water supplies are influenced. As previously mentioned, gratifying results have been secured in having phenolic waste treatment plants constructed at by-product coke ovens, and rapid progress is being made in providing needed sewage treatment works.

The control of tastes and odors in water supplies may be subdivided into two phases, namely: the prevention of tastes through control of the source of supply or the method of treating the water and, secondly, the removal of taste and odor producing substances which are unavoidably present in water supplies.

THE PREVENTION OF TASTES AND ODORS

Draining swamps. Many impounding reservoirs are located in streams draining watersheds containing swamp areas. In some instances such swamps are subject to supervision by the municipality served by the supply, in which case the municipality would be well justified in constructing drainage ditches to reduce the amount of organic matter leaching from the swamp area and in turn the concentration of decomposing organic matter contributed by the swamp. Such drainage operations also eliminate small pools, etc., in which algae growths are prolific and which serve to seed the reservoir with such organisms. The clearing of brook channels and the drainage of a swamp area tributary to one of the Port Jervis reservoirs in this way reduced the color of the water of this small tributary stream from about 200 p.p.m. to about 30 p.p.m.

Shallow coves in large reservoirs are also prolific sources of trouble due to the growth of aquatic vegetation and algae. It is frequently economical in the long run to construct a dyke isolating such an area or to eliminate the area by filling.

Copper sulphate treatment. Almost everyone is familiar with the use of copper sulphate for the control of microörganisms in reservoirs. Little modification has been made in the method of applying copper sulphate until recently. This is due to the fact that reasonably satisfactory results have been secured by the simple procedure of dragging crystals of the material in burlap bags over the surface of reservoirs by attaching the bags to rowboats or launches. Studies made by the Los Angeles Water Department, however, have indicated that this crude procedure is wasteful of the copper sulphate and does not permit precise dosage of the algaecide. For instance, if bags of copper sulphate attached to boats are dragged through water in parallel courses sufficiently far apart to result in a moderate dose of copper sulphate, the zones between the courses of the boat will not be subject to treatment. If, on the other hand, the boats are propelled in parallel courses quite close together, the total dose is larger than required. It is estimated that the minimum dose which can be applied by the older procedure is about 25 pounds per acre of water surface, whereas the required dose may be only 7 pounds per acre.

Furthermore, the older crude procedure does not result in uniform vertical distribution of the chemical, because the toxic effect is due to the copper sulphate and not copper carbonate and copper hydroxide formed by the reaction of the copper sulphate and carbonates of the water. The Los Angeles Water Department, therefore, has developed inexpensive equipment for scattering pulverized copper sulphate over the surface of a lake or reservoir so that the water is treated as the small crystals dissolve when sinking through the water.

The Los Angeles method briefly consists in pulverizing the copper sulphate so that the material will pass through a 16 mesh sieve, the larger crystals so formed sinking to a depth of about 20 feet before they dissolve, whereas the finer material sinks only several feet before dissolving. The powdered copper sulphate is distributed over the surface of the water by equipment driven by a one-half horsepower gasoline engine mounted in the stern of a launch. This engine drives a metal disc on a horizontal shaft which is parallel to the keel of the boat. A hopper containing the pulverized copper sulphate is so located that its spout terminates in the center of the disc so that the powdered material is fed from the hopper to the center of the revolving disc by which it is scattered. The rate of feed of the powder to the disc is controlled by an adjustable opening. It is claimed that this equipment will scatter pulverized copper sulphate over a strip of

water 40 to 50 feet wide in calm weather, whereas the powder is blown to one side for 100 feet or more by high winds. Twenty-eight to over 100 acres of water surface have been treated per hour, depending upon the size of the reservoir.

The size of the pulverized material is varied to secure more effective treatment of water at different depths, that is coarser material is used when the organisms are known to be present in the lower portions of reservoirs as in the case of many diatoms, whereas finer material would be used when destroying organisms growing near the surface, such as many blue green algae. This possibility of restricting the treatment to a limited depth of water results in great economy, because ordinarily the required dose is computed by using the total volume of water in a reservoir, although there are instances where the volume of surface water to a depth of 25 to 30 feet is used rather than the total volume.

A marked saving in the cost and effectiveness of the treatment has been secured through the use of this equipment. Consideration, however, is being given to the development of an engine driven blower to disperse powdered copper sulphate in the hopes that this equipment will impart the same speed to small particles as to the larger, so that the material of varying sizes may be distributed evenly over the surface of the reservoir.

The City of San Francisco has recently experimented with the use of a small engine driven centrifugal pump to distribute copper sulphate solution. Pulverized copper sulphate is injected into the suction pipe of the pump. The discharge pipe is connected to two manifolds, one on each side of a launch, whereby the copper sulphate solution is forced at right angles to the course of the boat over a zone of about 40 to 50 feet wide. It is claimed that this procedure has improved the effectiveness and rapidity of the application of the copper sulphate.

Baltimore City has utilized perforated triangular boxes attached on each side of a launch, which boxes are filled with pulverized copper sulphate. Water passes through these submerged boxes when the launch is propelled through the water, dissolving the copper sulphate. The rate of solution of the material and hence the dose applied to the water can be controlled by varying the speed of the launch and the size of the opening through which the water passes.

At times it is desirable to apply copper sulphate to shallow bodies of water where boats cannot be propelled. Satisfactory results have

been secured in such cases by attaching a net to an inner tube and by placing a bag of copper sulphate crystals within the float so constructed. A rope is then attached to the inner tube so that the device to be towed through shallow areas of reservoirs to destroy microorganisms frequently growing in such areas.

Continuous application of copper sulphate. The copper sulphate applied as indicated above is intended to destroy microörganisms. It is interesting to note, however, that New York City and Port Jervis are applying copper sulphate continuously to water entering the reservoirs so as to prevent the growth of microörganisms. The water entering the Croton reservoir of New York City is treated with a dose of 0.1 p.p.m. copper sulphate applied with dry feed equipment.

Mr. Horace A. Sheldon, Water Commissioner of Port Jervis, New York, has reported that copper sulphate is added continuously to the water entering reservoir No. 1 from the large impounding reservoirs. From June 1 to November 1, 1935 seven pounds of copper sulphate were added each day to approximately 3 m.g.d. of water, the material being dissolved and fed as a solution, giving a dose of 0.28 p.p.m. From November 1, 1935 to April 1, 1936 during cold weather, nine pounds of copper sulphate were placed in a bag and submerged in the entering stream, thus avoiding freezing difficulties. The copper sulphate dissolved slowly during the greater part of the 24 hour period, giving a dose of 0.36 p.p.m. From April 1, 1936 to date, a solution of nine pounds per day has been applied, but in addition 14 applications of copper sulphate have been made directly to the edges and upper portion of reservoir No. 1, with an average dose of 60 pounds to about 55 million gallons of water, or 0.13 p.p.m., although the actual dose applied to the water in the portion of the reservoir treated was higher than this average computed value. This treatment has prevented the growth of algae in this unfiltered supply and has eliminated complaints as to taste and odor.

This method of treatment is especially useful when reservoirs receive drainage from large swamp areas which cannot be eliminated and where the incoming water contains large concentrations of microorganisms. Continuous application of copper sulphate may be secured by using conventional solution or dry feed chemical dosing apparatus. It is feasible, of course, to use the chlorine-ammonia treatment for the same purpose when the reservoir is not too large and residual chlorine can be maintained throughout the body of water.

Mention should be made of the possibility of adding copper sulphate through holes cut on ice during winter weather. It occasionally happens that taste difficulties due to diatoms such as Asterionella or protozoa like Synura occur during the winter months when ordinary treatment of the reservoir is impossible. If holes are cut in the ice about 25 feet apart, it is possible to raise and lower bags of copper sulphate through the water and thereby control such growths to a considerable extent.

Experience has definitely indicated that the effectiveness of copper sulphate treatment depends upon microscopical examination of samples of water collected from reservoirs at varying depths at frequent intervals. In the absence of laboratory control of this treatment procedure, the copper sulphate should be applied every three to four weeks during the warmer portion of the year.

The chlorine-ammonia treatment. The chlorine-ammonia treatment of water to secure more effective disinfection and the elimination of algae growths and the prevention of chlorinous tastes is widely utilized, so little need be said at this time relative to the fundamentals of this treatment. About 62 supplies in New York State are treated with both chlorine and ammonia, there being a total of 330 supplies which are chlorinated. It is very desirable, however, to emphasize certain factors that should be borne in mind when preventing the occurrence of chlorinous tastes which incidentally are more common than should be the case and which have led to unfavorable reaction on the part of the public to the very essential chlorine treatment of most water supplies. In the first place, manual control chlorinators are used in many instances to treat supplies flowing at varying rates when in reality automatic equipment should be utilized. In some instances, however, the range in the rate of flow of water being treated is not excessive and chlorinous tastes can be prevented through the use of the chlorine-ammonia treatment, because moderate overtreatment of the water with chloramines does not produce objectionable tastes. In any case the determination of residual chlorine in the treated water should be made frequently to insure effective disinfection without the production of chlorinous tastes.

As previously stated, algae growths in equalizing reservoirs receiving treated water can be controlled through the use of the chlorine-ammonia treatment. Prechlorination with chlorine and ammonia also enables residual chlorine being maintained throughout coagula-

tion basins and through filter beds, thereby preventing the decomposing of sludge in coagulation basins and the growth of slime organisms in filter beds.

As is generally known, the ratio of chlorine to ammonia is usually three to one. It may be necessary, however, to materially increase the ratio of ammonia when taste difficulties are acute and in fact a ratio of one to one may be needed when chloro-phenol tastes are being prevented. Generally speaking, a higher ammonia ratio is required when waters containing appreciable organic content are being treated.

THE REMOVAL OF TASTES AND ODORS

The above discussion has referred to the prevention of tastes and odors. Attention will now be given to several procedures for removing tastes and odors which are unavoidably present in water supplies.

Generally speaking, surface waters exposed to natural aeration are of better physical character than water present in the lower portions of reservoirs, except when certain species of microörganisms are growing near the surface. For this reason, surplus water should be wasted from the lower portions of reservoirs by opening blow-off valves rather than letting an equal volume of "fresh" water pass over the spillway. The City of Oneida practices this procedure and thereby wastes the water containing most of the iron, manganese, and decomposed organic matter. For the same reason intakes in deep reservoirs should be fitted with multiple gates which permit water being drawn from varying levels. Experiences at Albany, Saratoga Springs, Oneida, LeRoy, etc., have definitely indicated that those in charge of water supplies should determine by sampling the character of water available at different levels, so that water can be drawn from the level furnishing the most satisfactory water under the given climatic conditions, etc

Aeration. Little need be said as to the advantages of aeration in removing volatile taste and odor producing compounds, such as hydrogen sulphide present in many well waters and essential oils liberated by microörganisms growing in reservoirs. Mention should be made, however, to the practice at Holland, New York, where aeration is used to remove hydrogen sulphide from well water. The Holland supply also is disinfected with chlorine, and it is interesting to note that the chlorine will react with any residual hydrogen sulphide present in the aerated water and completely remove it.

In general, aeration of raw water is justified irrespective of the degree of subsequent treatment because it reduces the quantity of activated carbon, etc., required in odor removal.

Superchlorination. Superchlorination, defined as the use of such high doses of chlorine as to require the subsequent use of a dechlorination agent, has been used in New York State only at Jamaica, N. Y., to destroy tastes due to gasoline leaching into the ground water. Experience in the treatment of the water supplies of Toronto, several suburbs of Chicago and elsewhere has definitely indicated, however, that very effective taste and odor removal can be secured by adding sufficient chlorine to the raw water at filtration plants to produce at least 0.5 p.p.m. residual chlorine in the filtered water. This residual is then removed by the use of sodium bisulphide, sulphur dioxide or beds of granular activated carbon. The total doses of chlorine required for this purpose may seem very large, being from 1.5 to 3.5 p.p.m., but the dose of chlorine may be less than the required dose of other chemicals used in taste and odor removal. Superchlorination, therefore, deserves to be studied to a much larger extent than has been the case in the past.

Activated carbon. Activated carbon is quite generally utilized in New York State as our records indicate its use at 40 filter plants. Heretofore this use has been restricted to powdered activated carbon except at Seneca Falls, and very recently at South Fallsburg, New York.

The South Fallsburg plant will be described at this meeting. It is notable that the South Fallsburg plant permits odor and taste control by both superchlorination and carbon treatment, because the carbon bed adsorbs residual taste and odor remaining after superchlorination, as well as the residual chlorine present in the filtered water. This new plant, therefore, should be watched with considerable interest.

The Seneca Falls installation consists of granular activated carbon placed to a depth of 6 inches in two of the six pressure filters. The four conventional filter units are used as preliminary filters and their effluent is passed through the two secondary units at twice the rate of preliminary filtration. Tastes and odors due to algae growths in Cayuga Lake are removed to a marked extent by this procedure, but the volume of granular activated carbon utilized is not entirely adequate and hence powdered carbon is being added to the raw water to insure completely satisfactory results. No data are available from New York State plants as to the relative cost of powdered carbon

when added continuously and granular carbon beds when replaced at periodic intervals.

It is impossible to review the large amount of information available as to the effective use of powdered activated carbon. Several cases may be cited, however, to indicate that the required doses of carbon during periods of extreme taste difficulties may be higher than many people realize. For instance, the Oshkosh, Wisconsin supply contains large quantities of decomposing organic matter, and doses of powdered carbon of 50 p.p.m. or about 400 pounds per million gallons have been needed for effective taste and odor removal. In a similar manner a total dose of 18 p.p.m. or 150 pounds per million gallons was required at Saratoga Springs to remove a similar taste.

Likewise the odors and tastes due to the recent decomposition of organic matter in the Ithaca reservoir were not effectively removed until there was added 8.0 p.p.m. or 70 pounds per million gallons of carbon to the raw water, 2.5 p.p.m. or 20 pounds per million gallons to the settled water, and 5 pounds of carbon were added to each filter bed of one-half million gallons capacity following the usual washing procedure. This reduced the filter runs from about 36 to about 8 hours. The indications are that equally effective results could be secured by adding less carbon to the raw water and somewhat higher doses to the filtered water, because carbon impregnated filter beds are more effective in taste and odor removal than an equal volume of carbon suspended in the water in coagulation basins. It is very desirable, however, to add a portion of the carbon to the raw water either separately or through the use of "black alum" or "activated alum," whereby odors from the decomposition of sludge are prevented and more effective over all results are secured. A good practice is to add a dose of carbon of 10 to 25 pounds per million gallons to the raw water at most times and to increase the dose when necessary by adding the carbon to the settled water or directly to the filter beds.

The effectiveness of adding powdered carbon directly to filter beds after they have been washed is such as to justify the mention of the practical problems involved. At the Saratoga Springs plant a weighed quantity of carbon, namely, 4 pounds per application, was placed in a shovel and was applied to the settled water first flowing into the filter bed immediately after each washing procedure. The carbon was dumped in the "forebay" of the filter bed and was effectively distributed throughout the filter area. At Richmond, Vir-

ginia, a suspension of carbon is prepared at a central point and distributed through special piping, terminating at the inlet to each filter unit, where a quick opening valve is located. The same procedure was used at Albany when taste from Synura was being removed. This more elaborate procedure is justified because of the convenience and the absence of dust problems.

The required dose of activated carbon may be determined by adding increasing doses until effective results are secured. In general, however, more definite and rapid results are secured by the use of laboratory stirring equipment, whereby several samples of water may be dosed with varying quantities of powdered activated carbon and water mixed for a definite period of time and then filtered through laboratory filter paper. In this way the effective dose can be ascertained in about one hour. It is a good procedure to use a somewhat larger preliminary dose on a plant scale and then to reduce the dose gradually until effective results are secured with a minimum dose. In general the activated carbon treatment will be effective if a sufficiently high dose of carbon is utilized. This, of course, may entail a considerable expense, reducing the length of filter runs and cause other practical difficulties, but the important fact is that attractive water can be produced when powdered carbon is used correctly at modern filtration plants.

Additional data are desirable relative to the direct application of powdered activated carbon to reservoirs to remove taste and odor producing substances as well as color. It frequently happens that conventional activated carbon treatment would be desirable but impracticable because of the absence of a filtration plant. The experience of the New Haven Water Company at Milford, Conn., therefore, is of interest because the water in a 15 million gallon reservoir having an objectionable taste and color due to the decomposition of organic matter, was treated with copper sulphate and powdered carbon by direct application. Water is pumped from this reservoir in a daily period of four to five hours and, hence, an opportunity existed for the sedimentation of carbon throughout a period of about twenty hours. The copper sulphate was applied in the usual manner with a dose of about 0.5 p.p.m. Some hours later, at the end of the daily pumping period, 1.5 p.p.m. powdered carbon was applied to the water in the reservoir. This was accomplished by placing a barrel in the stern of a rowboat. This barrel was fitted at the bottom with two small copper tubes extending on each side of the boat. A

suspension of the carbon was maintained in the barrel. Three men were required, namely; one to row the boat, one to add carbon and agitate the suspension, and the third to force water into the barrel by operating a small hand pump. Naturally, more economical results could be secured through the use of a small gasoline engine driven pump whereby the carbon could be injected into the suction pipe and discharged at right angles to the course of the boat, as in the case of copper sulphate application at San Francisco.

An important factor is that the preliminary copper sulphate dose results in the formation of copper carbonate floc which upon settling precipitates the carbon so that the water delivered the next day to the distribution system was free from this material. This treatment resulted in a reduction in color of from 40 to 10 p.p.m. and the musty, marshy taste was removed. This taste, however, returned in several days, apparently due to continued decomposition. It would appear that more definite results would have been secured had the dose been higher, judging from experience elsewhere with carbon treatment.

Four hundred pounds of "black alum," containing 10 percent activated carbon, were applied directly to the water in a 4 million gallon reservoir at Hillburn, N. Y., in the hope that the high color and swampy taste of the water could be reduced by coagulation and carbon adsorption. This treatment was effective in the partial clarification of the surface water, the color being reduced from 35 to 20 p.p.m., the turbidity from 10 to 5 p.p.m., and the taste and odor being reduced from distinct to faint. Unfortunately, however, water had to be drawn from near the bottom, where the floc accumulated. Even though the results were of limited value, this emergency treatment procedure should be borne in mind, because it might be very effective when water may be drawn from near the surface.

Control of distribution systems. It frequently happens that attractive water is pumped into a distribution system, but where the water delivered to the public has a noticeable taste and odor. This is usually due to the decomposition of organic matter in the pipe lines near dead ends, especially when the water is devoid of oxygen and contains appreciable concentrations of sulphates, which are reduced to sulphides by anaerobic decomposition. Such decomposition can be prevented by aerating supplies, coupled with frequent flushing of dead ends, and also by the use of chlorine-ammonia treatment of the water whereby an active disinfectant is present throughout the system. It should be remembered that aeration will increase the

corrosive of soft waters through the introduction of oxygen, so that in such instances chlorine-ammonia treatment is the more desirable.

Tastes and odors are occasionally due to the growth of crenothrix in distribution systems. The growth of these "iron" bacteria can be prevented through the removal of iron and manganese before the water is introduced into distribution systems. If iron removal equipment is not available, however, it is feasible to destroy the growths through the use of the chlorine-ammonia treatment, whereby the water throughout the system contains about 0.2 to 1.0 p.p.m. residual chlorine, depending upon local conditions. This treatment has been effective at Jamaica and Phoenix, N. Y.

Crenothrix growth in the Rhinebeck supply was almost completely eliminated by the use of copper sulphate in doses of about 0.25 p.p.m. applied on every third day. A somewhat larger dose applied continuously will be used in the future to completely eliminate this organism. In this particular instance the copper sulphate solution had to be forced into the well water being pumped into the distribution system by a deep well pump and, hence, a special solution pump was needed. One of the commercial chlorinators, designed for the application of hypochlorite solutions for disinfecting purposes, is used at Rhinebeck.

CONCLUSIONS

In conclusion it seems desirable to emphasize the value of the experimental method of determining the best method of taste and odor control required for a specific supply, and the necessity of frequent microscopical examinations of samples to determine whether microorganisms are present at various levels from which water may be drawn. Complaints by the public as to the condition of water delivered to their homes should be considered as significant until investigation indicates that complaints are unwarranted, so that all available information may be utilized. We wish to take this opportunity of assuring those in charge of water supplies throughout the state of the willingness of the Department to coöperate in the study of the origin and best procedures for preventing or removing tastes and odors from specific water supplies. Everyone should feel free, therefore, to communicate with our district engineers relative to such difficulties.

(*Presented before the New York Section meeting, October 15, 1936.*)

MODIFYING AN UNUSUAL FILTER PLANT TO OPERATE SUCCESSFULLY

By W. W. Hurlbut

(Engineer of Water Works, Bureau of Water Works and Supply, Los Angeles, Calif.)

An article on "Unusual Color Removal Plant,"[1] sets forth what many water works engineers have been considering radical innovations in filtration plant design inimical to the safe development of the art of water treatment and dangerous to communities which might adopt them. There has been a persistent demand by eastern engineers who have seen the Wilmington Color Removal Plant, which was constructed in 1932 and which had to be revised completely, for the writer to prepare an article which would bring up to date the experiences with color removal at that plant.

The points in the article just mentioned which have invoked special interest are the following: first, that ferric chloride using a dose of 0.2 grain per gallon with a color ranging from 100 to 125 p.p.m. instead of alum was better suited for the type of water to be treated; second, that the filter bed consisted of 10 inches of sand with an effective size of 1.0 mm. with a filter rate of 376 million gallons per acre per day and with wash water troughs set 10 inches above the sand surface; third, that the entire influent to the filter be through a grid discharging just below the sand surface to keep the sand surface roiled; fourth, that spent sludge be recirculated up to eleven cycles of reuse; and, fifth, that the coagulated material would all rise to the surface in the clarifier and no sludge would appear at the bottom. These and other novel innovations were an outgrowth of observations made on a 69,000 gallon pilot plant which had been constructed for experimental purposes. This plant did demonstrate that the color of the raw water could be visibly decreased by ferric chloride coagulation and was entirely successful as a popular exhibition. However, as later found out, not a single standard test for color was made of the raw or treated water during the entire life of the experimental plant; it was not equipped with a rate controller; and no records were kept of losses of head for different rates of filtration or of per

[1] Journal, 23: 5, May, 1931.

cent removals of color by different chemical doses. The demonstration unit operated periodically in 1929 and was dismantled that same year.

A 5 m.g.d. plant at Wilmington was designed during 1930–31 and was constructed the latter part of 1931. Except for the reducing of the maximum filter rate from 675 million gallons per acre per day to 150 million gallons per acre per day and of providing sludge removal devices in the clarifier the larger unit contained all the suggestions and innovations above innumerated. The proposed 15 m.g.d. plant at Lomita, referred to in the same article, was never constructed, principally because of the unsatisfactory performance of the 5 m.g.d. unit.

As a matter of record, the 5 m.g.d. plant was placed in operation on February 9, 1932. It handled a maximum flow of 1.5 m.g.d. and required a chemical dosage of 3.5 g.p.g. The final color was greater at all times than 35 p.p.m. Obviously, it was a complete failure and after several days run was shut down. The original ferric chloride feeding machine never did function and a crude feeding device had to be improvised. The influent grid had to be enlarged immediately. On February 24, 1932 the plant was again started and operated nine days at an average flow of 2.5 m.g.d. at a dose of 3 g.p.g. Still the final color was estimated to be over 35 p.p.m.

At this time R. F. Goudey was asked for recommendations and from March 30, 1932 to April 22, 1932 quickly made the following changes: (1) two ferric chloride feeding devices using constant head orifice controls were installed; (2) better initial mixing was secured by baffles; (3) coagulation in the four 10 feet square tanks 12 feet deep with violent agitation with circular paddles using a total of 15 H.P. was changed to an up-and-down flow by baffles giving a velocity of 0.3 foot per second at 5 m.g.d. flow with all power units removed; (4) the clarifier was improved by change of inlet arrangements by installation of squeegees on bottom blades, by decreasing speed of rotation from 20 to 55 minutes, by increasing the clarifier outlet weir length from 40 to 230 feet, and by raising the overflow level 9 inches; (5) the filter beds were renovated by replacing a poor grade of rock containing clay, mica, and decomposed granite and regrading new hard rock free of granite and mica particles according to standard practice; (6) the 10 inch sand layer with an effective size of 1.0 mm. diameter which was also light, flaky, and fluffy was replaced by quartz sand with an effective size varying from 0.35 to 0.45 mm. and its depth was increased to 18 inches (later to 22 inches);

(7) the wash water troughs were raised 8 inches which would have been more if structural features would have permitted; (8) all surface inlet grids were removed; (9) loss of head and rate indicator gauges were installed; (10) three rate controllers originally installed backwards were properly set; and (11) the rate of backwash was controlled to prevent disrupting of sand beds.

After these changes the plant was placed in operation and a flow of 2.7 m.g.d. required a dose of 3.0 g.p.g. to effect a color reduction to 15 p.p.m. This was the first time acceptable water was produced. Time out was taken to continue experiments with the addition of lime (1.6 to 2.0 g.p.g.), chlorination of sludge and with sludge circulation with and without chlorination. The average flow during this period of experimentation was 3.0 m.g.d.; the ferric chloride dose was

TABLE 1

Operating rates and dosages

OPERATING RATES	RAW WATER COLOR*	FERRIC CHLORIDE DOSE	FINAL COLOR	MIXING TIME	FILTERING RATE	SETTLING RATE	TOTAL OPERATION AND MAINTENANCE COST
m.g.d.	*p.p.m.*	*gr./gal.*	*p.p.m.*	*minutes*	*g./sq. ft./ min.*	*g./sq. ft./ day*	*cents per 100 c.f.*
2	32	1.0	13	75	1.0	800	3.65
3	32	1.0	13	50	1.4	1,200	2.65
4	42	1.4	13	37.5	1.9	1,600	2.15
5	50	1.6	13	30	2.4	2,000	1.85
6	58	2.0	13	25	2.9	2,400	1.65

* Varies according to combinations of wells in use.

3.25 g.p.g; and the residual color was 25 p.p.m. On June 24, 1932, Mr. Goudey's further recommendations were accepted and he was placed in full charge of the plant's reconstruction and its subsequent operation. His main contention was that the water should be properly conditioned before filtration. Without disrupting continuity of operation two 27-inch Turbo mixers of 20,000 g.p.m. capacity, one over the other, were installed in the first mixing tank and in addition 50 c.f.m. of free air was blown through filtros tubes just below the upper Turbo mixer to assist in the mixing and to drive off methane present in the water as well as carbon dioxide from the chemical reaction. This one change lowered the ferric chloride dose 0.35 g.p.g. The second step was to increase the mixing period from 10 to 30 minutes by installing two 20 feet diameter by 15 feet steel tanks equipped with paddle mixers which lowered the ferric chloride

dose 0.5 g.p.g. more. Other changes were made with but a few hours interruption, such as streamlining abrupt turns in all flumes to prevent breaking up of the floc, curved baffled inlets to the clarifier ahead of a deep baffle discharging influent into bottom 18 inches of the clarifiers, and keeping a layer of 0.35 mm. sand on the surface of the filters, permitted the plant to operate safely at high flows as indicated by table 1.

The plant actually operated at a flow of 6 m.g.d. for four consecutive months except for sixteen days when consumption requirements dropped to between 4 and 5 m.g.d. The maximum hourly flow through the plant has been 6.75 m.g.d. The changes in design not only succeeded in placing the plant on a satisfactory operating basis but increased the original designed capacity from 5 to 6 m.g.d.

FERRIC CHLORIDE AS A COAGULANT

Repeated experiments were made with alum with and without the pH adjustment and with sodium aluminate, but no combination would give an economical method of treatment. All alum dosage rates without pH adjustment produced flocs too fine to settle efficiently in a clarifier. By lowering the pH to 4.8 an alum dose of 0.5 g.p.g. could be used but this was not economical.

Ferric chloride, on the other hand, gave a good floc without pH adjustment at about 2 g.p.g. and by lowering the pH to 5.0 a dose of 0.4 g.p.g. sufficed. The cost of acid to depress the pH, together with lime to restore it, was greater than the saving in ferric chloride and accordingly all efforts to adjust pH were discontinued in favor of experimentation with other coagulants. The acid adjustment of pH was actually tried out on a plant run on a 5 m.g.d. flow in an effort to try to prove whether pH control could be made practical.

The variations in pH of Wilmington water as compared with Los Angeles aqueduct water with successive increments of weak acid is given in table 2.

To obtain a pH of 3.6 the Wilmington water takes 60 percent more acid than the aqueduct water.

The Wilmington water contains humates and tannates which in the presence of iron jell out and become food for bacteria causing the water to have tastes and odors. Filtration removes these substances and ferric chloride does it much more economically than alum. The original contention that ferric chloride was better suited for Wilmington water has proven correct.

Spent sludge was found to peptize, that is, bacteria caused some of

the iron to revert to the ferrous state and as such passed through the filters into the distribution system. Even with chlorination of returned sludge this trouble continued.

Ferric chloride needed as long a period of mixing as alum does and possibly even longer. It would appear that the sedimentation rate in a clarifier would favor ferric chloride but a 6 m.g.d. plant to secure 90 percent removal of suspended solids should have a clarifier 60 instead of 50 feet square as at Wilmington.

In the filters the sand growths became troublesome unless close attention was paid to periodic heavy chlorination of the sand beds. Every eight to ten days at Wilmington it was necessary, after cleaning a filter, to add chlorine at a rate of 1 pound per 24 square feet of sand surface by applying it to the inlet water until an 0.8 p.p.m.

TABLE 2

INCREMENTS OF 0.05 N H_2SO_4 TO 100 CC.	pH WILMINGTON WATER	pH AQUEDUCT WATER
cc.		
0	7.2	7.0
1	5.7	5.5
2	5.6	5.3
3	5.5+	5.2
4	5.5	4.8
5	5.4	3.6
6	5.1	3.1
7	4.5	2.9
8	3.5	2.8
9	2.9	2.8

residual appeared at the outlet and permit a contact period of ten minutes.

Experimental plants are of value only when the operation data in connection with them are complete and accurate in every detail. Otherwise, as in this case, errors in judgment necessitate costly alterations to bring the plant back to nearly standard design. An experimental plant definitely establishes what type of coagulant is best for any particular water under consideration.

The Wilmington plant was discontinued in October, 1935, on completion of a line from the main portion of the City since supplying the harbor area with aqueduct water. Capitalized operation costs of the Wilmington plant, together with the proposed 15 m.g.d. plant at Lomita, were sufficient to pay off the entire investment of the harbor aqueduct line in three years' time.

DENVER'S WEST SIDE FILTER PLANT

By L. R. Howson

(Alvord, Burdick & Howson, Engineers, Chicago, Ill.)

Chicago had its "Century of Progress." With respect to filtration, Denver illustrates a "half century of progress." Filtration was started at Denver when there were only about 1 per cent as many filter plants in the United States as there are today. The New West Side filter plant is the fifth step in Denver's filtration development. The Denver situation is unique in that the four former steps are all in operation at the present time.

The first plant built was of the English type consisting of 10½ acres of slow sand filters located at Kassler some 20 miles south of Denver on the South Platte River. These filters, built soon after 1890, have treated up to 30 m.g.d. of Platte River water. A few years later the first mechanical or American type filters were installed at Willard and South Marston. These were of the tub type and at normal water works rating have capacities of approximately 12 and 16 m.g.d. respectively, although they have frequently been operated at rates about 50 percent greater. These filters operate without mixing or coagulation, but ordinarily receive a fairly clear raw water which has had a lengthy period of plain subsidence in Platte Canyon Reservoir or Marston Lake. These filters of wood construction have outlived practically all of their contemporaries but have been maintained in service by good maintenance, assisted by liberal application of tin patches.

The North Marston plant,—the fourth built—has a nominal capacity at 2 gallons per square foot per minute of 50 m.g.d., but was designed for 70 m.g.d., using anthracite coal filtering medium of approximately 0.6 millimeter effective size and 1.85 uniformity coefficient. The water reaching these filters is aerated, has rather inadequate mixing facilities and practically no sedimentation.

ADDITIONAL FILTRATION CAPACITY REQUIRED

The antiquity of the tub filters and the growth in water demands have indicated the necessity of greater filtration plant capacity. By

1950 it is estimated that the maximum day's use of water in Denver will be approximately 157 m.g.d. Certainly prior to that time Willard and South Marston filters with an aggregate capacity of approximately 30 m.g.d. will have gone out of service, leaving only North Marston and Kassler filters, and the infiltration galleries. Additional capacity of 50 to 60 m.g.d. is indicated as necessary at that time, which for purposes of design is taken as the present. This capacity is being provided in a new plant known as the West Side filter plant built in conjunction with the Moffat Tunnel water diversion project. A description of the new plant will be better understood if preceded by a general discussion of the conditions under which it will operate, which of course influenced the design.

SOURCE OF SUPPLY FOR WEST SIDE PLANT

Up to the present time Denver has secured its entire water supply from the east slope of the Rocky Mountains. It has long been recognized that Denver's future growth would be largely determined by its water supply policies. Certainly if Denver did not provide an adequate water supply it would never need it. The capacity of the South Platte development is approximately 80,000 acre feet per year which is barely adequate to supply the present population of approximately 338,000 people, as evidenced by the fact that on about three years out of four in the last decade it has been necessary to place restrictions upon water use in Denver. The Moffat Tunnel diversion fully developed will approximately double the present supply.

The raw water supply for the New West Side filter plant will come from the Fraser River diversion, the physical and climatic conditions surrounding which materially affect the plant design. The West Slope water has a hardness of less than 2 grains per gallon as contrasted to the average hardness of the present Platte River supply of from 7 to 8 grains per gallon. It is estimated, based upon the excellent studies of Buswell and Hudson as reported in THE JOURNAL (1932) that the saving in use of soap alone resulting from the substitution of West Slope water for Platte River water will be equivalent to approximately $9.00 per acre foot, or $225,000 per year. Inasmuch as the sale or exchange value of the West Slope water for irrigation purposes is but approximately $2.00 per acre foot, the problem becomes one of so coordinating water requirements, the fullest utilization of direct flow water rights, storage reservoir capacity on the East Slope and filter plant capacity as to develop most economically for public use the maximum amount of West Slope water.

The average annual use of water in Denver is equivalent to approximately 65 m.g.d. (190 g.p.c. per day). During the irrigation season the use averages about 50 percent greater than for the other eight months with weeks at a time substantially 200 percent of the annual average. Fortunately the four months of greatest use for irrigation are also the four months of greatest run-off from the West Slope. The natural flow of the Fraser River resulting from melting snow at altitude exceeding 9,500 feet above sea level occurs most largely during the four irrigation months. The snow in effect, therefore, provides reserve storage for peak water supply demands of Denver.

During the summer irrigation season when West Slope water is flowing through the Moffat Tunnel, the New West Side filter plant will be operated at maximum capacity. During the remainder of the year the plant will be supplied from storage in the 12,000 acre foot Ralston Creek reservoir and will operate at a lower rate sufficient to utilize the full reservoir capacity before the next year's diversion and realize the maximum savings in power now used for pumping at the high service stations.

PLANT SITE

The plant location was largely determined by available topography. The requirements for a site combined sufficient elevation to supply by gravity as much of the high level areas now served by pumping as practicable with reasonable proximity to the high service areas. A very desirable site was found approximately three and one-half miles west of Denver between 20th and 26th Sts. The site is at such elevation that by incorporating in the design a liberal clear well of 10 m.g.d. capacity and a 60-inch discharge pipe line it will be practicable to entirely close down the Ashland Avenue high service pumping station, effecting an annual saving of approximately $35,000. There is now under consideration the further extension of this high pressure main to the East Side high service area which will effect an annual saving in Capitol Hill and University Park station operations of an additional $30,000 per year.

INLET CONTROL

The water flow to the filtration plant from Ralston reservoir some 8.6 miles northwest is through a 42-inch reinforced concrete pipe line having a carrying capacity of 100 C.F.S., or about 125 percent of filter plant rating. The head on the pipe line at the mixing chamber will vary from 0 at 100 C.F.S. flow to approximately 180 feet static.

The prevention of surge in the line and flooding in the plant are important matters.

The mixing chamber into which the pipe line discharges is 40 feet square by 15 feet deep. The water will enter this chamber at velocities varying from 1½ to 14 feet per second. Surge control is automatic through a valve of the cone plug type actuated by the water level in the sedimentation basins some 300 feet distant. These basins have an area approximately 300 feet square, which is the primary reason for choosing them for the basis of control rather than the relatively small mixing chamber into which the line discharges. A one-inch fluctuation in the basin water level control represents about 1¼ minutes at peak rates of flow. A 4-inch variation in level would store the peak rate for 5 minutes. As the valve would be in the process of closing during this interval, approximately double the period would be available in actual operation. With this slow controlled operation little, if any, surge is anticipated. However, as a precautionary measure, the inlet side of the cone valve is provided with two 8-inch automatic pressure relief valves which are so connected as to discharge freely into the mixing basin. Their operation will so relieve the pipe line as to keep the head within the static range.

In order to provide against cavitation in the partially closed cone valve with the flow at high velocities, an equalizing pipe is connected from the mixing chamber to the inlet side of the valve.

PLANT LAYOUT

The topography of the site selected is such as to lend itself to an economical plan for the present 56 m.g.d. construction, as well as for future enlargement to double that capacity. The city purchased a 40 acre tract. The topography is generally rolling with an average slope of 5 feet per hundred. The slopes are fully utilized by locating the settling basins on the higher ground filters adjacent and with clear water reservoir on the lower ground, all structures being designed substantially so as to have all foundations on original ground and to balance cuts and fills. The settling basins, clear water reservoirs, wash water tank and dirty wash water cistern are entirely underground.

MIXING FACILITIES

Mixing will be in two steps, first a rapid and then a slow mixing. The rapid mixing will be effected in a chamber 40 feet square by 15

feet deep immediately adjoining the head house and chemical feeding facilities. Mixing will be accomplished by the swirling action created by the tangential entrance of the influent water at high velocity. At plant rating the quick mixing chamber will provide about 4 minutes retention.

The type and character of mixing are designed with relation to the water to be treated. The Fraser River water is very soft, carries little turbidity and reacts very slowly with alum and lime. Experiments in the laboratory showed that with mixing of from 10 to 15 minutes only a fine pin floc was formed, but that if the mixing period were extended and stirring provided for longer periods, the floc coalesced, and for periods in excess of 30 minutes a good quick settling floc was produced. Accordingly, the plant design provides for a 40 minute slow mechanical stirring by flocculating equipment of the Dorr type. The peripheral velocity of the paddles will be approximately $1\frac{1}{4}$ feet per second.

The flocculating and sedimentation basins are in one structure of three compartments, each approximately 90 by 290 feet in plan and 15 feet in depth. Three hours of quiescent settling follows 40 minutes of slow stirring. The velocity of flow through the basins will be approximately $1\frac{1}{3}$ feet per minute. The basins are of the straight flow through type with a baffle provided midway of the tank, so constructed that all water is required to flow over the top of the baffle, in effect dividing the settling basin into two substantially equal compartments operating in series. This design is provided to obviate short circuiting and facilitate settling.

The combined flocculating and sedimentation basins are of the flat slab box type of construction. The roof is covered with one foot of earth for protection of the concrete and with ventilating and access manholes at convenient locations.

The water enters the flocculating end of the basins through a rectangular closed channel in the roof of which there is an inclined slot extending the entire width of each of the three basins. The water passes from the closed conduit to the basins through this slot which is so inclined as to deflect the current backward. The width of the slot is so designed as to effect uniform distribution across the width of the basin.

The outlet is somewhat similarly controlled. The upper compartment of the outlet duct extends entirely across each basin with a submerged weir of uniform cross section extending the entire width as well. At the center of each basin is a downdraft sluice gate con-

trolled through which the settled water discharges into the lower outlet conduit. Uniform distribution is therefore effected through submerged weirs for both the inlet and outlet to the basins assisted by the intermediate baffles.

Particular attention is directed to one part of the specifications for the basins which requires that as soon as excavation is down to grade the top of the finished subgrade must be covered with a skin coat of concrete, a minimum of $\frac{3}{4}$-inch in thickness. This insures against subsequent disturbance of the subgrade and prevents settlement from that cause as well as providing a clean base upon which to place steel and perform subsequent operations. Observation at the West Side plant and on other work where this practice has been followed indicate that the additional cost, which is slight, is well justified. The contractor in this case states that he would install such a skin coat on the next job of this type whether or not it was specified or paid for.

FILTERS

From the sedimentation basins the water passes to the filters through a 72-inch conduit to a connection with the raw water channel at the end of the pipe gallery furthest removed from the head house. This same conduit will carry the water for delivery in two directions when the filter plant capacity is double.

The filter plant consists of ten units, each having a capacity of 4 m.g.d. at normal water works rating of 2 gallons per square foot per minute. With the excellent character of water and the complete pre-treatment facilities provided, the design rate has been stepped up to 2.8 gallons per square foot, giving a normal rated plant capacity of 56 m.g.d.

The filters are what is ordinarily termed the central gullet type in which each bed essentially consists of two units, each having a capacity of 2.8 m.g.d. A single set of control valves, however, operates both sides of the unit having a total capacity of 5.6 m.g.d.

Laterals are of cement lined cast iron pipe 4 inches in diameter spaced at 9-inch centers and with $\frac{7}{16}$ inch holes in the bottom at 9-inch centers.

The gravel bed is somewhat deeper than ordinary and more closely graded. The gradation in sizes is that developed simultaneously for both the Milwaukee and Denver plants. It consists of five layers having a total depth of 24 inches, varying in size from $2\frac{1}{2}$ to $1\frac{1}{2}$ inches

in the bottom layer to ¼ to ⅛ inch at the top. On top of the gravel a 5-inch course of torpedo sand will be placed and on top of that 22 inches of filter sand specified to have an effective size from 0.45 to 0.50 millimeter and a uniformity coefficient of 1.25 to 1.50.

Troughs are of reinforced concrete so spaced as to require a maximum horizontal flow of water of 2½ feet. All valves are hydraulically operated from a central control table. Each table is provided with a floc detector of the Baylis type and each hydraulic valve control will be provided with an illuminated precision indicator to show corresponding position of the valve or sluice gate.

Raw water and wash water meters are provided. Venturi type controllers are installed on each filter unit and a master control for the combined flow from all units.

All water level and flow indicating registers and dials are assembled in a central location convenient to the office, chemical feed and filter operating gallery. All dials on the individual operating tables, at the gauge panels, and on all chemical feeding machines are illuminated.

The pipe gallery is unusually commodious and provides free access to all valves and piping. This is partly accomplished through placing the main effluent collecting conduits outside the gallery under the filters and by placing the raw water waste discharge conduits at the rear of the filters.

The specifications require that wherever the excavation is carried below the finished grade upon which concrete is to be placed, the area so excavated must be filled with Class B concrete placed at the expense of the contractor.

Excavation beneath the top soil, was in a firm gumbo or adobe type of soil excellently adapted to carry the relatively uniform light loading of structures of this type. The soil loadings under most of the plant vary from ½ to 1 ton per square foot. Earth under column footings carrying concentrated loads is loaded to 2 tons per square foot.

CHEMICAL FEEDING FACILITIES

Chemicals will be brought to the plant by truck, unloaded inside the building and raised by electric elevator to the chemical storage floor which is the third floor of the head house. From that point chemicals will be fed by gravity. Chemical weighing and feeding facilities are provided for handling alum, lime, sodium aluminate,

powdered activated carbon, ammonia and chlorine with points of application so laid out as to give the maximum flexibility and reliability in plant operations. Feeding equipment for dry chemicals is of the gravimetric type by which the rate of chemical feeding is controlled by synchronous motor driven weights on the scale arm. Chlorine and ammonia machines will be housed on the second floor in separate rooms provided with exhausters for operation in case of emergency. Chlorine will be fed from ton containers. Chlorine and ammonia containers will be stored on the first floor of the building directly underneath the feed machines.

CLEAR WATER RESERVOIR

The topography of the filter plant site lent itself to a design by which the filter floors were built directly on the excavated ground thus obviating the heavy design for 1,000 pounds per square foot loading required where built above the clear well as is frequently done. The clear well is built independent of the filter plant proper. The effluent from the several filters discharges into two rectangular conduits each 6 feet by 7 feet, one located each side of the pipe gallery and directly under the front of the filters. These conduits converge into a 6-foot concrete conduit discharging into the 10 million gallon clear water reservoir, the size of which is partly determined by the requirements of high level storage in the Ashland Ave. and Capitol Hill districts. The clear well is in two compartments, and is entirely covered with earth and so located as to approximately balance cuts and fills. Its design is similar to that of the sedimentation basins thus permitting a maximum re-use of forms on the two structures which were built under one contract. Roof is of flat slab construction.

WASH WATER CISTERN

In view of the fact that the filters will be washed at rates as great as approximately 70 cubic feet per second (equivalent to 36 inches rise) and the fact that disposal of wash water must be in one of the local irrigation ditches of limited capacity, it has been necessary to install a wash water detention basin. This basin is located immediately in front of the filter building entirely underground. It is 50 feet square by 12 feet deep sufficient to hold approximately two complete filter washes. Outlet from the cistern is to the Agricultural ditch through a 20-inch pipe line. During the summer the wash water, amounting

to approximately 1½ million gallons per day, will be disposed of for irrigation purposes. During the winter when there is no water in the ditch and freezing would result from the disposal of filter wash water in the ditch, it is planned to pump the dirty water back to the mixing basin and thus through the plant. During the winter the wash water will amount to but from 100,000 to 200,000 gallons per day. The sedimentation basins will store the wash water deposits until spring when it is practicable to discharge to the ditch.

WASH WATER STORAGE

Wash water storage is provided in a reinforced concrete reservoir located on the highest ground on the site approximately 40 feet above the filter level. This tank stores 225,000 gallons underground. Connection between the wash water tank and the pipe gallery is through a 36-inch pipe.

The concrete has been of uniformly high quality. It was specified as consisting of one sack of cement to 190 to 245 pounds of sand, and from 325 to 380 pounds of gravel or crushed stone, mixed with 50 to 60 pounds of mixing water, and a total maximum of 600 pounds of aggregates per sack of cement. The concrete was specified with a minimum compressive strength of 3,000 pounds per square inch in 28 days. The strength of concrete as placed has been tested throughout. In the 114 twenty-eight day specimens tested the average strength has been 4,820 pounds per square inch with only one specimen below 3,000 pounds and that a specimen on which the 7 day and 28 day tests both were recorded as 2,820 pounds. As the 7 day test was near the average of all of the 7 day tests, the 28 day test is indicated as not consistent. The average of the 7 day tests was 3,100 pounds per square inch. These specimens for test were compacted by rodding only. As the concrete in the structures is compacted by spading, tamping and electric internal vibrators, it is believed to be of even greater strength than indicated by the test cylinders.

The reinforced concrete design is based upon 850 pounds per square inch stress in the concrete and 18,000 pounds per square inch in the reinforcing steel. As the concrete tests show an average 28 day strength of 4820 pounds per square inch and the steel is of hard grade with elastic limit exceeding 50,000 pounds per square inch it is evident that very liberal factors of safety were embodied in the design. Under similar specifications on the 200 m.g.d. filter plant for Milwaukee where larger quantities and costs are involved, the unit

stresses adopted are 1000 pounds per square inch for concrete and 20,000 pounds per square inch for steel.

Floors of basins are steel trowel finished. Roof slab surfaces are wood floated.

After placing concrete was kept wet for three weeks during curing. Floor and roof concrete was flooded behind low earth dikes. Walls were kept well sprinkled. Although there are no expansion joints, all structures being completely monolithic, careful inspection shows uniform curing with freedom from shrinkage cracks.

The 12,203 cubic yards of concrete placed under contract No. 10 required 19,154 barrels of cement, the average of 1.57 barrels per cubic yard.

PUMPING EQUIPMENT

The flow through the plant and to the city is entirely by gravity. However, it is necessary to pump the wash water and at certain seasons of the year to return the dirty wash water to the sedimentations basins. For this purpose there are provided three wash water pumps, each having a capacity of 5 m.g.d. The clear water pumps take suction from the clear well and discharge to the wash water main and thus to the wash water basin. The dirty wash water pumps take suction from the wash water cistern and discharge to the rapid mixing chamber. All pumps are located underneath and in an extension of the pipe gallery in a very compact and economical layout.

SUPERSTRUCTURE

The superstructure is constructed using a local grey brick with stone and terra cotta trim. The building is 104 feet by 270 feet in plan dimensions. That part over the filters is but one story high. The head house is three stories in height. That part of the building over the filters is lighted solely from skylights and the operating gallery monitor. The exterior walls resemble a panelled garden wall perfectly blank so far as openings are concerned. Light for the individual filters is provided through a skylight over each filter having an area equivalent to approximately 20 percent of the filter surface.

The roof over the filters is of reinforced concrete on structural steel beams. Each filter area approximately 44 feet by 36 feet 8 inches is entirely unobstructed by columns. The concrete roof is covered with 1½-inch cork insulation to reduce condensation as well as conserve heat.

Office, laboratory and all chemical feed and control apparatus are conveniently centered to facilitate operation with a small personnel. The interior of the filter room is of gray pressed brick the same as the exterior, with the exception of the operating gallery aisle, which is of terra cotta. The roof of the operating gallery, which is 20 feet in width, is of vaulted ceiling type held by longitudinal beams and struts of reinforced concrete constructed above the roof line, acting as ties. The inside of the ceiling is entirely plain.

Heating is installed as a part of the operating table assembly. Heat will be provided by a stoker fired coal burning boiler. The operating gallery has a high parapet and low curtain wall to minimize convection currents, thus reducing heat losses and condensation to a minimum.

GROUNDS

Facilities are being provided for convenient sprinkling of about 15 acres of the grounds through an underground distribution system with fixed valved connections and portable nozzles. This system will be laid so as to drain during the winter. Raw water will be used for sprinkling, utilizing the excess head above the regulating valve in the 42-inch pipe line from Ralston reservoir. When the filter plant is operating at capacity, approximately 25 to 30 pounds pressure will be available at the sprinkling nozzles. There will be approximately 150 fixed outlets for which 20 portable spray nozzles will be provided.

COST

All of the filter plant construction has been placed under contract with the exception of outside piping. The contracts let to date are as follows:

No. 10—Sedimentation and clear water basins	$274,950
Cement furnished by City	45,778
No. 11—Filtered structures	295,875
Cement furnished by City	17,925
No. 12—Filter equipment	168,790
No. 13—Pumping equipment	4,330
No. 14—Mixing equipment	13,420
	$821,068

The outside piping contract (not yet awarded) is estimated at $44,000 making a total cost of the filter plant, exclusive of engineering and land, approximately $865,000, or the equivalent of $21,600, per

million gallons based upon normal water works rating of 2 gallons per square foot per minute, or $15,500 per million gallons, based upon the design rating of the plant.

PERSONNEL

The Moffat Tunnel project of which the West Side filter plant is a part, is being executed under the direction of the Board of Water Commissioners—Col. Herbert S. Crocker, Consulting Engineer, in charge. Alvord, Burdick and Howson prepared the plans and specifications for the West Side filter plant with Victor A. Matteson associated on architectural design.

(*Presented before the Rocky Mountain Section meeting, September 23, 1936.*)

SUPERVISION OF CROSS-CONNECTIONS BY THE NEW JERSEY STATE DEPARTMENT OF HEALTH

By J. B. Baty

(Assistant Sanitary Engineer, State Department of Health, Trenton, N. J.)

In approaching the subject of cross-connections in public water supplies, it is with a belief that water works officials, and others associated in the water works field, are more or less familiar with the potentialities involved, that is, the advantages gained through flexibility of operation but more frequently the risks and hazards to public health produced. The matter of cross-connections is by no means a new issue. It attained national recognition in water works practice and public health supervision of public potable water supplies many years ago. It has remained, nevertheless, a live issue, growing in importance, with various national, sectional and state organizations and associations of persons engaged in water works and public health activities intensely interested in the sanitary protection of public potable water supplies. Departments of health of the various state governments, equipped with legal authority, have not been idle in the performance of duty in regard to this important phase of public health protection.

For purposes of clarity, it is important to define cross-connections or physical connections as they are referred to in this paper. The New Jersey State Department of Health has established that

"A physical connection shall be considered as any cross-connection, bypass, valve, pipe line, auxiliary intake, or other similar device which permits or may permit any flow of water into an approved public potable water supply from any other water supply unapproved by the Department of Health of the State of New Jersey, or any source of water supply not fully treated in accordance with the terms of the provisions of the permit issued for or the rules and regulations governing the supplying of such water for public potable purposes by the Department of Health of the State of New Jersey."

A committee appointed by and reporting to the American Water Works Association in 1933, for the purpose of its report stated, briefly,

that "A cross-connection may be defined as any physical connection by means of which water may flow between a public or private potable supply and a non-potable supply." Many other organizations and associations have established definitions of cross-connections or physical connections, all of which have a common underlying principle.

Just as there are several purposes served by a public water supply aside from domestic consumption, there are several reasons for the existence of physical or cross-connections between public water supply systems and sources or systems of private water supplies. Probably, the two examples of cross-connections which have been most prominent and most common in this state are: a connection between a public potable water supply and a private non-potable supply, arranged to permit the use of either or both for industrial purposes; and, a connection between a public water supply and a private fire protection system, which permits the public supply to maintain pressure on sprinklers and hydrants at all times while the private supply, through the medium of a fire pump or elevated tank comes into service only at times of fire or test. The advantages to the owners of the cross-connections in these cases are obvious. In the former case, a non-potable supply is frequently satisfactory for manufacturing purposes and can be obtained at a very low cost in comparison to the greater cost of the public supply; consequently, when an abundant supply is required in manufacturing, economy justifies the use of the non-potable supply. It is desirable, however, to hold the public supply in reserve in case of a breakdown or other emergency. On the other hand, if the public supply is depended upon for industrial and manufacturing purposes, any interruption of an adequate public supply might cause serious damage to stock or equipment. In the second case, a cross-connection existing for fire protection purposes due to inadequacy of either the public supply or the private supply in the matters of pressure and volume available, needs little explanation. Should a serious fire occur at an industrial plant, the combined supplies, public and private, might be required. Undoubtedly, a dual source of water supply at any large premises produces lower fire insurance rates.

Within the last two decades the problem of cross-connections has received more attention in public health circles and in water works practice, resulting in tremendous improvements in the safeguarding of water supplies used for domestic purposes. The economical

advantages to be gained by cross-connections should not even be considered at the expense of the health of the populace. The hazard to public health produced by the possible infection of public water supplies with water from polluted sources through faulty or unprotected cross-connections, with a consequent epidemic of a water-borne disease, supports the abolishment of all cross-connections with non-potable supplies. A study by two eminent investigators, Wolman and Gorman, on this subject, entitled "The Significance of Water-borne Typhoid Fever Outbreaks, 1920–1930" disclosed that unprotected cross-connections as a cause rated first in the number of cases of typhoid, second in the number of outbreaks, fourth in the number of dysentery cases and fourth in the total number of typhoid and dysentery cases.

An act of the New Jersey legislature entitled: "An Act to secure the purity of the public supplies of potable waters in this State," approved March 17, 1899, originally authorized that

> "The State Board of Health shall have the general supervision with reference to their purity, of all rivers, brooks, streams, lakes, ponds, wells, springs or other reservoirs in this state, the waters of which are, or may be used as, the source or sources of public water supplies for domestic use, together with the waters feeding the same, and shall have the authority, from time to time, as they deem necessary or proper, to examine the same and to inquire what, if any, pollutions exist, and their causes; . . ."

A supplement to this act, approved April 21, 1909, further set out that

> "No person or corporation now or hereafter engaged in the distribution or sale of water for potable purposes shall deliver to any consumer any water, which, in the opinion of the Board of Health of the State of New Jersey, is polluted, contaminated or impure, or which is obtained from any source which, in the opinion of the Board of Health of the State of New Jersey, is or may become polluted, contaminated or impure, unless purification by filtration or other means acceptable to the Board of Health of the State of New Jersey shall be accomplished before such water is distributed."

Other subsequent supplements, amendments and acts added to the duties of the State Board of Health and its successor, the State Department of Health, relating to the protection of the purity of public potable water supplies. The State Department of Health, in the discharge of these obligations, imposed by law, has investigated and continues to investigate any possible sources of pollution or contamination to public potable water supplies. It is not unmind-

ful of the other purposes to be served by public supplies of water, however, believing that the deliverance of pure water for human consumption takes precedence over all other purposes, the department set out to curb cross-connections to public water systems. It was impelled to this end by two notable examples in this state of what cross-connections would do.

In 1922, polluted water from the Wallkill River at Franklin, New Jersey entered the potable water distribution system through a leaky single check valve during a test of the fire pumps. The New Jersey Zinc Company, who owned the water supply system, spent a large amount of money each year to filter and chlorinate a surface water supply, making it absolutely safe for potable purposes. Water was analyzed frequently, establishing proof that the regular supply was beyond suspicion. The mere leakage of a single check valve connection with an unapproved supply defeated the extreme care given to the operation of the approved supply and caused an epidemic of typhoid, consisting of 114 cases and resulting in 18 deaths.

At Rockaway, New Jersey, in 1923, a defective single check valve was discovered and from convincing information obtained it was concluded that the temporary greater pressure on a certain fire supply system caused the water from the fire supply to flow into the municipal water system. The fire supply was polluted by the effluent of a septic tank which received excretions of a typhoid carrier. Forty-one cases of typhoid and 4 deaths resulted.

The New Jersey State Department of Health continued in its endeavors to eliminate these hazards to public water supplies which supplies in other respects were well protected and safe for domestic use, and, conformed to all requirements under existing legislation. Finally, on October 6, 1925, the New Jersey State Department of Health adopted a preamble and resolution upon the use of cross-connections, which was later amended as to the date of continuance. Copies of the resolution were sent to water companies and municipalities serving water for potable purposes. It placed the department on record as opposing cross-connections of any kind, permitting the continuance of cross-connections until January 1, 1928, provided such cross-connections were equipped with double check valves of the Special Factory Mutual design or equivalent. In order to enforce the discontinuance of cross-connections, an amendment to the Sanitary Code, calling for such action, was presented to the Members of the Department of Health at a meeting in April, 1927. The matter

was laid over for further consideration and a hearing was scheduled for June 7, 1927. Representatives of the Manufacturers Association of New Jersey, various industrial plants, municipal water departments and water companies in New Jersey were invited to attend the hearing. Only one side of the question was presented—the fire protection side. About twenty persons entered their protests against absolute elimination of cross-connections, stating that it would be a great hardship on the manufacturers of New Jersey if such procedures were carried out. At the meeting in January, 1928, it was recommended that the matter of cross-connections be held in abeyance until the June meeting of the department and that meanwhile the new improved all bronze double check valve be investigated. The device was investigated and tested by representatives of the Bureau of Engineering of the Department of Health. The engineers were satisfied with its performance and concluded "that with frequent inspections and careful maintenance the double check valve of the all bronze type, located on cross-connections, will afford reasonable protection against pollution of the potable water supplies."

Ultimately, after very careful consideration, a resolution was adopted by the New Jersey State Department of Health at a meeting held on September 18, 1928 providing for the addition of a new chapter, Chapter 13, to the State Sanitary Code. The new chapter, entitled "Certain Physical Connections Upon Public Potable Water Supplies Pronibited" included beside the definition of a physical connection, which was recited in the first part of this paper, the following regulation,

"Regulation 2. That after April 1, 1929, physical connections shall not be permitted, except where such physical connections existing on April 1, 1929, include two all bronze check valves with rounded rubber facing, two gate valves with indicator posts or rising stems and drip cocks and gauges for testing, and such physical connection is located in a vault or pit of watertight construction readily accessible for inspection; and,

"Provided, That the application for the continuation of such a physical connection is made to the local board of health having jurisdiction and is approved by such local board of health, the date of continuance may be temporarily extended by the Department of Health of the State of New Jersey."

The all bronze double check valves referred to in the State Sanitary Code and in this paper are of the type developed by the Associated Factory Mutual Fire Insurance Companies, generally called

the Factory Mutual or F. M. type. Over twenty years ago, the Factory Mutual Companies designed a special double check valve equipment for fire service cross-connections. The check valves were made with bronze working parts and rubber facings so that they would have tight seats. Then for each equipment two of these valves were put in series, thus greatly increasing the efficiency, as the probability that both would leak at the same time was extremely remote. The two check valves were installed between gate valves in a pit, where they were readily accessible for examination. In addition, the check valves were provided with pressure gages and test cocks so arranged that the tightness of each check valve could be verified in a few minutes. Only a few years ago the device was improved by making the double check valves with bodies and covers of bronze so that all iron would be eliminated and the accumulation of rust avoided.

In considering the legal aspects of Chapter 13 of the State Sanitary Code, it should be pointed out that the code is not a law, however, it is authorized by law. An act of the legislature entitled "An Act to increase the efficiency of public health protection in this State, to abolish the State Board of Health, and to create a State Department of Health and to prescribe and define the powers and duties of such department," approved April 14, 1915 authorized that the Department of Health "shall enact a State Sanitary Code, which shall contain such rules and regulations, the observance of which, in its opinion will promote health and prevent disease." The provisions of Chapter 13 are statewide in scope and there is no fine connected with the violation of its provisions. Since actual cases are on record in this state where cross-connections have proved to be a menace to health, as referred to previously in this paper, it is the firm belief of the Department of Health that the enforcement of the provisions of Chapter 13 of the State Sanitary Code would be substantiated in court proceedings when and if necessary.

Following the enactment of Chapter 13, at a meeting of the New Jersey State Department of Health, held on October 30, 1928, the procedure for making application for an original permit to maintain or establish a physical connection between a public potable water supply and an unapproved water supply was established. This procedure placed the burden of responsibility of certifying, relative to compliance with the provisions of Chapter 13 of the Sanitary Code, and recommending that a permit be issued first upon the local board

of health having jurisdiction, but it also required that the application contain the recommendation of the municipal water department or the water company supplying the potable water. Original permits were issued to owners of physical connections, where the proper protective devices were installed and the applications were properly endorsed, for a one year period ending April 1, 1930. It has been the policy of the State Department of Health to extend the original permits by issuing renewal permits for one year's continuance on April 1, of each year, if the applications for such renewal permits bear the proper endorsements and include satisfactory information regarding the testing, internal inspections of the check valves and the results of such tests and inspections. Most local boards of health provide at least a quarterly test of the installation and at least an annual inspection of the interior of the valves.

The requirement of the State Sanitary Code for the installation of the special protective devices, in order to continue physical connections which were in existence on or before April 1, 1929, almost automatically eliminated many such connections in this state. In many cases they were not absolutely essential, but retained as a matter of convenience. The service, however, did not warrant the expensive installation of the all bronze check valves.

There are several methods for eliminating physical or cross-connections and yet be benefited by dual water service. One method, frequently suggested by the State Department of Health, where pumping is employed only in part, is by means of an elevated tank or standpipe. The unapproved supply can be pumped either directly to the private distribution piping or to the tank, and the potable water may be supplied to the elevated tank or standpipe through a separate pipe terminating in an open end above the highest level which the unapproved supply can reach. A sufficiently large overflow pipe should be provided. A ball float valve can be provided on the potable water supply pipe if it is desired to fill the tank or standpipe automatically. Another method, especially adapted to situations where industrial water has to be pumped, is by means of an open tank with the fill pipe from a potable supply located above the overflow. The service pump can then take suction from the non-potable source or from the open tank filled from the potable supply. Another similar arrangement is for the service pump to draw water from a cistern or reservoir which can be filled independently, without a cross-connection, from the potable and non-potable

sources. A very simple and inexpensive method of eliminating industrial cross-connections is by means of a flexible pipe connection normally attached to the piping system of one of the water supplies. In case of emergency, this flexible pipe can be swung over for connection to a pipe of the other supply. The inlet end is connected by a union to either the normal or emergency water supply system and the discharge end is connected by a standard ball joint to the distribution piping of the mill. By this method of elimination, either one of the water supplies may be used but not both at the same time. Because of this feature, the swinging joint is not suitable for the elimination of fire service cross-connections. The arrangement is especially adapted to situations where the two supplies are under pressure and do not require pumping.

There are at present 142 establishments in New Jersey continuing cross-connections under permits issued by the State Department of Health. The Department is far from being certain that these permits cover all of the cross-connections still existing in the state. However, as soon as the existence of one is brought to the attention of the department, steps are taken to cause its elimination, or if it were in existence on or before April 1, 1929, to issue instructions relative to the proper procedure in compliance with the State Sanitary Code if it is desired to continue the connection. In the matter of discovering isolated and unprotected cross-connections, which are a violation of the State Sanitary Code, the State Department of Health is dependent upon, to a great extent, the local authorities, both the local boards of health and the water departments or water companies.

Within the past twelve months, the department in coöperation with a certain local health officer in the state investigated and discovered five cross-connections between the public potable water supply in a municipality of the state and separate private hotel supplies. Through the coöperative efforts of the State Department of Health, the local board of health and the local water purveyors, all of the five cross-connections were eliminated.

Frequently, when the matter of a violation is brought to the attention of the owner of a cross-connection and he is familiarized with the regulations relating to the same, it is his desire to have the department issue an approval of the private supply. In some cases, particularly where the private supply is derived from a deep well and the entire system is, apparently, amply protected, the quality of the

private supply is not particularly questioned; however, the department could not recognize the supply as a source of potable water unless it came directly under the department's constant supervision. Such supervision of private supplies is without legal background. The State Department of Health obtained an opinion from the Attorney General of the State in the matter or the scope of its supervision over water supplies in the State. Based on that opinion, at a meeting of the department on January 10, 1933, a resolution was adopted, defining a public potable water supply, under the health regulations of the department. The following extracts from that resolution established the department's position relative to private water supplies:

"The said Attorney General under dates of April 25, 1929 and May 8, 1929, issued opinions to the Department of Health of the State of New Jersey . . . that the Department has no jurisdiction in the furnishing of water to hotels and other establishments delivering water to guests and others merely as an accomodation as such constitutes a private supply; . . . " It was resolved that " . . . it is the opinion of the said Department of Health that, in order for sources of water supplies to be considered as public potable supplies, they must represent sources of supply from which water is distributed or sold to consumers for potable purposes in eight or more dwellings and/or properties, and where water from sources of supplies is distributed or sold to less than said number of dwellings and/or properties such supplies will hereafter be considered as private sources of water supplies and which supplies come within the jurisdiction of local boards of health having control over the territory wherein such supplies are located."

As a result of discussions before the Department upon cross-connections existing in the City of Atlantic City between the established public potable water supply and private water supplies, including the private hotel supplies; and, upon the safeness of the public water supply, a committee of members of the State Department of Health met with interested citizens in Atlantic City on April 2, 1930.

There was introduced into the discussion an "Agreement Between the City and Coöperative Power Plant Owners," dated 1917, which referred to "Atlantic City High Pressure Fire Service." In this agreement certain requirements specify that the owners of certain water supplies shall connect their private supplies to the city supply when requested by the city and to allow the city to install special instruments upon the private supplies. In view of this agreement, it was recommended:

That the New Jersey State Department of Health consider the above private supplies as additional sources of the public water supply of the City of Atlantic City; that these private water supplies be analyzed by the Department at least four (4) times a year and be subjected to the same inspection control as upon the existing public supplies; that the Department of Health move for the abatement in Atlantic City of all other cross connections—not included in Recommendation No. 1—or the installation of the protective devices in accordance with Chapter 13 of the State Sanitary Code; that the City establish a laboratory for the examination of water, and, that the supervision of such laboratory be under a man well qualified (a) in the art of water purification, (b) to make sanitary surveys and water analyses and (c) to interpret such analyses, this employee to be a "full-time" man.

The City of Atlantic City was in accord with the recommendation for the establishment of laboratory control and advised that they would move for the introduction of the necessary ordinance to carry out the recommendation.

Similar situations arose in Vineland, New Jersey, and Bridgeton, New Jersey, wherein reciprocal agreements were drawn up between a certain industry in each municipality and the municipality respectively, such that in case of emergency the industries could supply water to the public distribution systems. In these cases it was definitely shown that the auxiliary supplies might be needed by the municipalities and applications were made by the two municipalities to the State Department of Health for approval of the supplies, the source of which are deep wells, as auxiliary public water supplies. The approvals were issued.

It is the desire of the State Department of Health to impress upon all officials of municipal water departments, water companies and local boards of health that the responsibilities for the existence of cross-connections with the consequent hazard to public health should be shared with the Department of Health. The owners of protected cross-connections under permits are the parties benefited by such temporary privileges; however, the water departments or water companies derive the revenue through the sale of water to such consumers and it should be their obligation to participate in the burden of protecting the safe quality of their supply from the potential hazard of cross-connections. It is further the desire of the Department to point out that the provisions of Chapter 13 of the Sanitary Code do not compel any water purveyor or local health board to allow cross-connections which existed prior to April 1, 1929 and that the State Department of Health will not issue permits for continu-

ance of the cross-connections if the local officials desire to eliminate them and decline to endorse the applications. It is never too late to start an investigation for hidden cross-connections on your own water works system. Your coöperation in locating and eliminating them or reporting the occurrence of them to the Department of Health is earnestly solicited.

(Presented before the New Jersey Section meeting, October 23, 1936.)

IRON AND MANGANESE IN WATER

By George E. Willcomb

(*Superintendent of Filtration, Albany, N. Y.*)

This paper was written with the following objects in view:

(a) To call attention to the fact that manganese and iron troubles are more common than is generally supposed and that many operators have manganese in their raw waters long before any indication of trouble is noticed by the consumers.

(b) The chemistry of compounds of manganese.

(c) Specific cases of trouble from iron and manganese.

(d) Corrective measures.

(e) Experience with manganese at Albany.

The presence of iron and manganese in a water supply is a nuisance and unless these compounds are removed the consumers will eventually be put to a lot of annoyance and expense to say nothing of the worry and extra labor enforced upon the water superintendent and filter operator.

The reactions involving iron and manganese are similar and will be treated as common in this paper. Manganese reactions are much slower than those involving iron, especially oxidation reactions. Where these differences are of importance they will be emphasized.

As will be explained in the section on chemical reactions the probability of trouble being experienced from the presence of manganese in a water is presaged by the combination in which it exists in the raw supply. If the soluble manganous salts oxidize very slowly they may pass intact through the purification works into the distribution system unless such works are designed to remove them. Generally, the salts oxidize either before reaching the plant or in the mains and the characteristic dark brown floc is precipitated. In two of the plants under the writer's control the manganese oxidizes very slowly and one of the operators was astonished when told that his plant effluent contained manganese far in excess of the amount that is generally considered to give trouble.

As has been pointed out many times, the interference of manganese with the ortho-tolidine reaction has been the means of warning many an operator of the presence of manganese in the raw water. Although such interference is the rule, many instances occur where it exists in the soluble bicarbonate or manganous hydrate form so that in the cold very little reaction takes place with the hydrochloric acid of the tolidine reagent and as a consequence no chlorine is produced to give a false endpoint.

With the introduction of the vacuum type chlorinator a most potent means of identifying the presence of manganese was established. The minutest traces of manganous compounds are oxidized and deposited as a telltale brown film on the inside of the glass jar. Even at Albany where the manganese oxidizes with difficulty its presence is always indicated by this means.

When unoxidized manganese enters the mains the tendency is for it slowly to oxidize and precipitate. This may take in some instances as long as two months, in other cases even longer. The troubles as finally developed may be classified as follows:

(a) Formation of dark colored deposits in pipe.

(b) Formation of dark spots on white toilet fixtures and on white fabrics undergoing the process of washing, as water containing manganese when mixed with a strong alkali secretes manganese dioxide under the influence of oxygen.

(c) In paper mills brown spots are formed on the stock. In breweries the fermentation is disadvantageously affected; while in dye-works the color becomes spotty.

CHEMISTRY OF COMPOUNDS OF MANGANESE

In reading the various papers on manganese the writer has always been impressed with a desire to review his chemistry, particularly with reference to manganese reactions. These are especially troublesome for the reason that it is bonded with some atoms of some substances by one link and with others by two links. Thus, the manganous series of salts may be regarded as bivalent and the manganic as trivalent.

Manganese resembles chlorine in that it forms a series of oxides and acids. It also plays the part of a base-forming element and in this capacity forms the two series of manganous and manganic compounds. Manganous salts are the more stable and by mere contact

with the air are not as a rule converted into the manganic series. On oxidation, manganese preferably forms manganous salts and those of permanganic acid. As the results of oxidation a long series of oxides and their corresponding hydroxides are formed. When treated with an energetic oxidizing agent in the presence of alkalies, all the oxides are transformed into manganates. On the other hand, if a manganate is reduced in the presence of an acid, the tendency to form manganous compounds shows itself.

The principal form of manganese in nature is the black oxide, manganese dioxide or Pyrolusite. It probably dissolves in water as manganous sulphate or bicarbonate. Ordinary chemical analytical methods fail to determine what form manganese occurs in raw water because the necessary processes easily change its value so that the original state in which it exists is lost. The sulphates and bicarbonates are not stable in dilute aqueous solution and by hydrolysis are converted into soluble manganous hydrates and the resultant acids.

From the foregoing one must become impressed with the important part played by oxidation in the production of manganese compounds. The rôle played by oxygen is rendered doubly difficult to understand by the fact that oxidation is effected both by plain chemical and bio-chemical agencies, with the latter playing an obscure but important part.

Kühr (1) states that the plain chemical oxidation of a saturated solution of manganous bicarbonate in raw water requires a high pH, possibly as high as pH 10, to effect complete oxidation and precipitation. He also demonstrated that besides being capable of oxidizing dissolved manganese at a pH 10, notwithstanding the fact that the oxygen of the air might be inactive, yet the manganese bacteria can just as well oxidize in an acid medium of pH 4 to 5.

By experimentation Kühr was able to establish the fact that manganese bacteria are able to oxidize manganous compounds into manganic both in acid and alkaline solutions forming a jellylike substance which continuously absorbs fresh manganese from the water thus bringing about a continuous oxygen cycle. This biological action may take place on grains of sand, pieces of gravel and on concrete surfaces submerged in water.

The chemistry of the production of iron and manganese in well waters and impounded supplies is not thoroughly understood but it is reasonable to believe that it proceeds as follows. In the first place

it has been the general experience that precipitation troubles have not occurred until the reservoirs have been in service several years, and secondly, rarely have the inlet waters to the reservoirs been found to contain iron or manganese in any appreciable amount. How then do these minerals finally accumulate in the water to the extent that they become a general nuisance by staining fabrics and incrusting pipe? The answer is that the mineral matter is leeched from the ore-rock scattered throughout the reservoir bottoms, and its concentration is cumulative, requiring several years before it reaches a concentration of over 0.1 part per million.

The main agency in the production of iron and manganese is the presence of organic matter in the water and its gradual decomposition by bacterial growths. The decaying vegetation lying on the bottom of the reservoir gives rise to a vast bacterial flora and as a result many organic acids like tartaric, lactic, and humic are formed which are eventually turned into carbonic acid. The presence of oxygen stimulates the bacterial action and accelerates the decomposition of vegetable matter. The oxygen balance appears to be the determining factor in the resolution of iron and manganese oxide. Experimentors have found that these oxides are little affected by carbonic acid but are readily dissolved by reducing agents followed by the action of weak organic acids.

Although most impounding reservoirs carry plenty of oxygen in their lower strata during the summer months, even up to 60 to 70 percent saturation, a zone undoubtedly exists at the bottom where the biological activities are at a maximum during the warm summer months and where the diffusion of oxygen from the water to the decaying plantlife is not great enough to supply the oxygen demand, hence such a condition results in the formation of reducing compounds. We thus have established the paradoxical condition where both aerobic and anaerobic action exist at the same time adjacent to one another. The resulting reducing compounds attack the mineral oxides which are rendered soluble by the weak organic acids and eventually transformed into bicarbonates.

The picture then is this: as a result of bacterial decomposition manganese and iron salts go into solution as carbonates and slowly oxidize. Unless subjected to a vigorous oxidation in a highly alkaline solution at a treatment plant they tend to pass into the distribution system. At some filter plants bacterial growths on basin walls

and filter sand cause precipitation troubles at these points. If the conduit bearing the water citywards is concrete the zone of high alkalinity next to the concrete surface may precipitate the manganese. Plant operators whose underdrain systems are composed of concrete may well be apprehensive as to the ultimate clogging of such piping. Indeed, this trouble has been experienced many times and most ingenious have been the corrective measures employed such as the planned production of carbon dioxide and added acid solvents.

Iron and steel mains also harbor growths which result in manganese precipitation with the consequent lowering of their carrying capacities. It is thus the general experience to find a gradual diminution in the manganese content of the water in passing from the reservoir through the distribution system. Where precipitation does not occur conditions are likely to be found unfavorable to the production of bacterial flora and poor oxidation conditions combined with low alkalinities.

While most of the foregoing has pertained to the formation of iron and manganese in impounded supplies it is likewise descriptive of the conditions met with in well waters. In the case of the latter the carbon dioxide and weak acids dissolve the mineral deposits in the soil resulting in the formation of soluble bicarbonates, sulphates and nitrates. In the case of ground waters the concentration of mineral salts is generally much greater than is the case with surface waters.

SPECIFIC PRECIPITATION TROUBLES

As would be expected the concentration and prevalence of iron and manganese vary greatly according to location and season. The following table taken from data contained in papers by Weston (2) and Carpenter (3) shows the distribution of manganese according to location, in parts per million.

	GROUND WATER	SURFACE WATER	ACID MINE WATER—SURFACE
Maximum	53.4	2.5	31
Minimum	0.03	0.1	0.2

The following data on iron and manganese of typical New York State supplies were furnished by C. A. Holmquist, Director, Division of Sanitation, State Department of Health. In most cases they represent maximum figures.

LOCATION	PARTS PER MILLION	
	Iron	Manganese
Long Beach	6.0	
Delanson	0.7	2.2
Le Roy	0.03	1.6
Waverly	0.6	0.4
Oneida	0.8	0.56
Stillwater	3.0	0.2
Valley Stream	2.8	
Orchard Park	0.9	0.32

From the above tables it will be noted that iron and manganese vary greatly both as to location and whether they are derived from surface or well supplies. In New York State the well supplies are the more concentrated and the surface supplies vary their content according to season and the depth from which the water is withdrawn.

With such variations in chemical constituents as is indicated in the above tables it would be surprising if a great many interesting experiences with precipitation troubles were not recorded in the technical literature. Abstracts of some of the more recent articles follow.

Hale (4) gives an account of the sudden occurrence of manganese in New York City water due to the overturning of Croton Reservoir caused by an abnormally sharp drop in temperature. Another paper by Hale (5) describes the deposition of manganese dioxide on the inner surface of the concrete Catskill Aqueduct. A discussion is given as to whether the deposit was of bacterial or chemical origin and the conclusion reached that it was caused by a zone of high alkalinity existing between the water surface and the concrete resulting in a resolution of the soluble manganese in the water by virtue of the excessive alkalinity.

Baylis (6) gives an account of the sudden and unexpected increase of manganese in the Baltimore tap water in 1923. It is interesting to note in this case that the cause of the trouble was due to biological agencies in which certain bacteria living on organic matter surrounding the sand grains in the filters were able to produce organic acids that dissolved the manganese dioxide stored up in the sand and on the basin walls. This soluble manganese was afterwards precipitated in the mains.

Weston (2) describes the gradual production of manganese com-

pounds in the water of Wanaque Reservoir and the effect of the presence of manganese on the ortho-tolidin reagent.

Boynton-Carpenter (3) cite many cases of manganese in West Virginia streams caused by the effect of acid mine drainage. The effect of manganese precipitation on filter sand is described, also remedies for counteracting these troubles.

Janzig and Montank (7) demonstrate that manganese is redissolved from the sand of idle filters. They indicate that biological action was an important factor in the process of redissolving manganese.

REMOVAL OF IRON AND MANGANESE

From the section on the chemistry of manganese it is evident that many methods are available to the designer for the removal of iron and manganese. Practically all of them depend upon either the direct chemical or bio-chemical means of precipitation. In the direct chemical, rapid oxidation is necessary, accompanied by a high pH of approximately 9.5. In this process iron salts are used as the coagulant and the pH is regulated by lime. This method is well adapted to the conventional filter plant treating an impounded supply in which manganese becomes more and more in evidence with the passage of time. Bean (8) describes a successful adaptation of this process at Providence.

In some cases where bacterial growths of iron and manganese bacteria develop readily the mineral salts are removed by aeration followed by preliminary rapid and slow sand final filtration. In the case of well waters the constituents to be removed are well known in advance from many analyses and such waters being more or less constant in mineral concentration are easily handled by conventional design. As such waters are invariably high in carbon dioxide, most efficient aeration is necessary; and if manganese is very high, necessitating prolonged aeration, a combination splash-tray and coke contact process, followed by rapid filtration completely remove the precipitated hydrates. The plant at Memphis, Tenn., is a good example of this process on a large scale.

Weston (2) states that while hard waters, high in iron may be purified easily; soft waters low in iron and pH value, and high in organic content, present many difficulties necessitating in some instances the use of an oxidizing agent like chlorine or permanganate to reduce the inhibiting organic matter.

Iron and manganese may be removed by zeolites regenerated with permangate. This process has the advantage of operating well without technical supervision and is well adapted to small installations although many large ones have been found to be economically feasible.

Hale (9) describes the installation of a most interesting plant on Long Island treating a well water high in iron and devoid of oxygen, with lime alone without aeration. The lime is added sufficient to change all free carbon dioxide into bicarbonate and cause the formation of a few parts of normal carbonate. All of the iron is removed as ferrous carbonate and hydrate on the sand of a pressure filter. The sludge finally accumulates in the sand to the extent that it has to be removed periodically by eliminating the lime for a while and allowing the carbon dioxide dissolve mineral matter.

ALBANY EXPERIENCE WITH MANGANESE

Albany's experience with manganese runs parallel with that of many other cities in the east using an impounded source of supply. Its experience is interesting in that it represents average conditions met with by most plants. By this is meant that no especial details were incorporated in the design to combat manganese so that when troubles acutely developed corrective measures had to be introduced that were made possible by the general plant layout.

Hannacroix Creek is the main source of supply. It rises in the foot-hills of the Catskills and flows through a very sparsely settled watershed principally devoted to farming. The water is soft and the manganese content very low. Soil conditions on the watershed gave no indication of the presence of manganese or iron ore. Alcove Dam impounds the creek waters, flooding an area of 1440 acres and at the spillway-line 618 feet above mean low water, the amount of water stored is 13.5 billion gallons. The area was cleared of buildings, brush and trees but no attempts were made to remove the top soil. The reservoir was completed in 1930 and by the spring of 1932 was full to the flow-line. It will thus be seen that the stored water was acting on the subsoil about two years before the reservoir was placed in commission in December, 1932.

The first indication of manganese was when the 100 m.g.d. Loudonville distribution reservoir was filled in the fall of 1932. At this time the concrete side slopes were colored a dark red and it became apparent that manganese was a factor to be coped with in the operation of the new filter plant.

The new 40 m.g.d. filter plant located at Feura Bush is of conventional design and is located midway in the 22 mile line of 48-inch cast iron pipe carrying water from the dam to the city. It is thus evident that the conditions are excellent for the deposition of manganese on the inside of the pipe. The filter plant is interesting in that it has an high pressure jet-nozzle aerator housed in a permanent building, mechanically ventilated and heated so that it is in commission the year round. The mixing basins are of the gravity type and built in three units of 10 minute retention each. They may be operated in series or in parallel, giving velocities of 0.9 or 0.3 feet per second respectively. One or all of the units may be operated as conditions dictate. Each basin is unique in that the first pass is through over and under baffles, the remainder of the flow being through round the

TABLE 1

Operating year 1933

	RAW WATER			CLEAR WELL			PERCENT REDUCTION OF MANGANESE
	Maximum	Minimum	Average	Maximum	Minimum	Average	
June	0.16	0.07	0.11	0.07	0.06	0.06	45
July	0.13	0.05	0.08	0.06	0.03	0.04	69
August	0.18	0.07	0.14	0.08	0.06	0.07	61
September	0.20	0.08	0.15	0.07	0.02	0.04	80
October	0.83	0.15	0.43	0.38	0.05	0.22	74
November	0.42	0.39	0.40	0.31	0.27	0.29	31

Results in parts per million, manganese.

end baffles. The advantage of this type of construction is, that three different chemicals may be introduced simultaneously and adequately mixed in the three over and under passes.

From the discoloration due to manganese on the slope walls of the reservoir referred to above, it was evident that the plant must be regulated to reduce manganese troubles to a minimum. As a most efficient coagulation process embodying the precipitation of alum reacting at an optimum pH adjusted by means of sulphuric acid had been incorporated in the plant design, it was decided to operate the first year with this alum process alone. A factor that lent encouragement to this decision was that the water might be withdrawn from the impounding reservoir at four different levels, 14.5 feet apart, and thus keep above the stratified manganese at all times except during the fall overturns.

Table 1 gives manganese figures for raw water and pure well during the operating year 1933. The water during the entire year was withdrawn from one point 34 feet below the surface.

From table 1 it will be noted that the manganese slowly increased at the bottom as the summer progressed reaching a maximum of 0.83 p.p.m. during the fall turnover in October. The standard plant process was able to keep the manganese in the pure well below an average of 0.07 p.p.m. on all months except October and November at which time the maximum reached 0.38 p.p.m. with a corresponding reduction of only 31 percent. At no time during the year were any complaints received about discolored water or stains on clothes. The conclusion is reached that the manganese oxidizes very slowly and that what deposition there is takes place on the inside of the conduit and mains.

During 1934 the same procedure was followed and the water was withdrawn from the 34 foot level. Following were the manganese data for the year.

RAW WATER			CLEAR WELL			PERCENT REDUCTION
Maximum	Minimum	Average	Maximum	Minimum	Average	
0.83	0.00	0.10	0.38	0.00	0.07	50

During 1935 it was decided to take advantage of change of reservoir outlet to the utmost inorder that the raw water might have as low a manganese as possible. Accordingly the point of outlet was changed five times, the endeavor being to withdraw the water from the bottom as much as possible in order to escape the surface algal growths during the summer and maintain the temperature of the water in the mains at the lowest point possible.

The following table gives the manganese data for 1935:

RAW WATER			CLEAR WELL			PERCENT REDUCTION
Maximum	Minimum	Average	Maximum	Minimum	Average	
1.31	0.01	0.16	1.14	0.01	0.08	53

From the foregoing tables it will be noted that the maxima of manganese tend to increase yearly during the fall overturn and at such times the percentage removal is at a minimum resulting in

excessive amounts in the clear well, amounting at times to 1.14 p.p.m. It was therefore decided to do some experimentation with iron salts as a coagulant, also to try out oxidation by means of chlorine and alum coagulation at a high pH on a plant scale.

The experimental apparatus used by Dr. Thompson (10) had been left intact and it was decided to modify this apparatus so that it could handle the raw water treated with lime and iron. An experimental coagulation tank was therefore set up and the plant raw water dosed with varying amounts of lime and ferrous sulphate, the settled water being fed to the glass experimental filters located in the pipe-gallery. This plant was operated by the regular filter operators and samples collected every two hours. The average results obtained on 10 experimental filter runs are given in table 2.

TABLE 2

Average results obtained on 10 runs of experimental filter

(2-inch diameter operating at rate of 2 gallons per square foot per minute. Coagulant: Ferrous sulphate 1.3 g.p.g. calcium hydrate 0.7 g.p.g.)

	RAW WATER	FILTERED EFFLUENT
Color	18	7
Turbidity	2	0.1
Hardness	38	34
Total alkalinity	32	34
Bicarbonate alkalinity	32	30
Carbonate alkalinity	0	4
Total iron	0.05	0.21
Manganese	0.13	0.03

From the experimental results in table 2 it was evident that the lime and iron process could be depended upon to produce a water low in manganese and of satisfactory color. At the time of the experiments the outlet from the reservoir was so selected as to withdraw a water of minimum manganese content, hence the filter was not operating under a high manganese load. The increase of iron in the effluent from 0.05 to 0.21 part per million was far from satisfactory and it is probable that the iron content could be decreased by more careful adjustment of the coagulants.

One disturbing feature was noted in the effluent of the experimental filter runs using the lime and iron process. This was a tendency for a slightly sweetish taste to develop in the effluent. Of eight observers asked to give their reaction of the taste of the filtered

effluent, four noted a sweetish taste quite different from that of the regular city water coagulated with alum and of a much lower pH. Whether such a sweetish taste would be developed in actual plant practice is problematical. However, its very presence in the experimental effluent was disconcerting as the regular city water is quite without taste and the slightest change would be noted by the consumers as demonstrated by many past experiences.

The first attempt on a plant scale to remove manganese by oxidation was begun on July 24, 1936 by prechlorinating the aerator effluent to the extent that it had a 1.0 p.p.m. actual excess. This was gradually cut down until the actual excess was 0.6 p.p.m. The manganese content of the raw water at this period was 1.74 and that of the filtered effluent without pre-chlorination 0.97 p.p.m. It was intended to build up the pH of the prechlorinated water with lime until its value was at least 9.0 but long before this could be done a medicated or iodoform taste developed in the city tap water which was registered as Medicated-4 on the plant log. It was apparent that prechlorination could not be employed under such conditions as to manganese and the pre-chlorination was immediately cut out.

As several articles had appeared in the literature pertaining to the removal of manganese by regular alum coagulation accompanied by a reaction pH of from 8.0 to 9.0, it was decided to try this method out on a plant scale. It was reported by Greenwich, Conn., that by adjusting the pH of the water coming onto the filters to 9.6 the manganese could be removed without an accompanying increase in color. It is generally recognized that increasing the pH of a water in which the alum floc has already been formed tends to peptize the floc, resulting in the formation of pin-head flocs accompanied by an increase in color of the effluent. Owing to the multi outlet weirs of the Albany settling basins it was not feasible to add the lime at this point. The procedure followed at the present time is to add all the alum under pressure to the aerator influent, adjusting the latter such that the jets rise 25 feet giving maximum oxidation. The floc is formed almost instantly and is conditioned by passing through two 10 minute intervals each, mixing basins. At the entrance to the third 10 minute basin the lime is added to give a pH at the present time of 8.1. It is intended to increase the lime gradually should the efficiency of manganese removal fall off. The amount of alum added at the present time is 0.8 grain per gallon.

Table 3 gives average results of raw and clear well waters using the above procedure.

From table 3 it is evident that on an average of 72 percent of the manganese can be removed by this procedure. The color reduction is satisfactory and no resolution of the floc has taken place as is indicated by the low soluble alumina and turbidity of the effluent. The following manganese figures are rather significant: Raw 0.18−, Basin Effluent 0.16−, clear Well 0.05 p.p.m. They indicate that very little work is done by the settling basins in the removal of manganese and that most of the hydrate is taken out by the passage through the sand. One might look for washing troubles under such

TABLE 3

Chemical data using high pH with alum coagulation

(Alum added 0.8, lime 0.3 g.p.g. Reaction pH after adding lime 8.1. Results in p.p.m.)

	RAW WATER	CLEAR WELL
Color	20	8
Turbidity	2	0.002*
Oxygen consumed	3.2	2.3
Hardness	36	38
Alkalinity	34	32
CO_2	3	0
pH	7.3	7.9
Iron (Fe)	0.05	0.04
Manganese (Mn)	0.18	0.05
Soluble alumina (Al_2O_3)	0.05	0.07

* Clear well turbidity determined with Kleinman Nephelometer.

conditions, but up to the present the sand has washed well without any apparent coating of the grains. This process ought to be capable of caring for the manganese all through the turnover period after which time the pH of the coagulated would be adjusted to normal and the resulting carbon dioxide would dissolve any accumulation of manganese that had coated the sand grains.

(*Presented before the New York Section meeting, October 15, 1936.*)

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WATERWORKS PROBLEMS OF THE SMALLER MUNICIPALITIES

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The general nature of the title of this paper permits such a wide scope that no attempt will be made to limit the subject matter to unusual problems or those peculiar only to the smaller municipalities, nor can it be hoped to cover every problem. No doubt some of these problems have been ably dealt with before and the author begs the indulgence of those who are better informed than he is.

The first problem in a small town or village may be considered a pre-natal one. Every village whose population approaches 1000 people needs a waterworks system, because the needs of a family in a village are not materially different from those of a family in a great metropolis. The first problem that is presented to the municipal council is one of finance and the second, source of supply. Other problems are easier of solution.

There is a popular opinion that the establishment of a waterworks system involves a heavy expenditure and a substantial increase in taxes but this is in reality seldom the case. The writer has in mind a town of 900 people where a system was installed at a cost of $45,000.00. They have no industries to contribute to the annual earnings, but the project is being financed by a two mill charge for fire protection and water rates per family varying from $0.75 to $1.50 per month. The plant operates automatically with off peak power so that operation and maintenance charges are almost nil. While no accurate figures are available it has been estimated that the higher insurance rates and the cost of individual wells and power pumps in only a part of the town would cost annually as much as the entire waterworks system. It is therefore apparent that the problem of finance is largely one of education.

LEGAL ASPECTS

From a legal point of view, the construction of water supply systems have to be authorized by a money by-law which must be

voted upon by the property owners, or ordered by the Department of Health except in the case of works already established when "extensions" may be made under Cl. 2. Chap. 399 of the Municipal Act. The distribution system may be similarly authorized or may be installed as a local improvement.

In any case the approvals of the Department of Health and of the Municipal Board are necessary.

A money by-law anticipates that sufficient money will be raised through the mill rate to pay the interest and principal on the debt over a period not exceeding 30 years. Actually this is not done. Each family is charged a water rate. The sum of these makes up the major part of the necessary finances. The balance is made up out of the mill rate, together with the cost of operation. This seldom exceeds 2 mills even in the smallest village. When a waterworks system is operated by a separate board that board bills the municipal treasurer for hydrant rental or fire protection. If the amount so obtained is sufficient to make the system more than self-sustaining the surplus is turned over to the treasurer, if not, the treasurer makes up the balances. The hydrant rental charge is analogous to the Hydro street lighting charge.

The laying of watermains as local improvements is usually confined to extensive new areas, where revenue from water rates is not available in advance of construction.

The question of a source of supply is one which has delayed the establishment of new systems in the smaller centers, but as this is a problem which is common to both new and long-established systems, it will be dealt with later.

For the purposes of this paper the writer has divided small waterworks systems into two types, those having a surface supply and those having wells as the source. Problems peculiar to each type will be discussed, then the common problems.

SURFACE SUPPLIES

Among the surface sources of supply are large lakes and rivers, inland lakes and creeks, springs, and underdrainage. A supply derived from a large lake or river has the outstanding advantage of unlimited quantity. Difficulties are due to intermittent turbidity, contamination, high temperature, and sometimes to ice and unpleasant tastes. To minimize turbidity the intake should be laid as far from shore as finances will permit. The inlet should be 4 or 5 feet off bottom and so designed to keep down the entrance velocity.

The water should be treated with a suitable coagulant, passed through settling tanks and then filtered and chlorinated. Water works systems in the smaller municipalities have been often designed with pressure filters and no provision for pre-sedimentation. Excessive turbidity and no opportunity for flocculation creates problems of operation that cannot be overcome. The mud penetrates the filters to such a depth that backwashing is difficult and the excessive amount of sediment requires very frequent washing with consequent loss of net capacity. Waters that are not turbid such as at Chippawa may be successfully and economically filtered with pressure systems. Most waters along the Great Lakes are subject to turbidity at times due to wind action, and require settling tanks in advance of the filters. In such cases it will be found that gravity filters can be built at no greater cost than pressure filters. They have the very great advantage that the surface is visible to the operator and he does not have to rely on rule of thumb and assume that the filter medium is in good condition.

To reduce contamination the location of the intake should be determined with the greatest of care. It should be kept away from creek outlets, traffic lanes, and the sewage outfalls of larger neighbors. High temperature can best be avoided by carrying the intake into deep water, preferably twenty feet or over. It is also helpful to use an elevated tank in preference to a standpipe of such a capacity that it will be emptied at least once per day. In some instances larger rivers such as the Detroit at Amherstburg, although comparatively deep, will not supply cool water. Here large boat traffic is so dense that the warm shore water is continually being mixed with that in the deeper channel.

Unpleasant tastes are not as common in supplies from large lakes or rivers. The location of the intake away from shore and remote from factory outfalls minimizes this trouble. In case of disagreeable tastes, modern practice offers many kinds of treatment that will control the offender. This is the subject of considerable study at present time in the larger cities and literature on the subject is continually appearing. The important point to remember is that each case has to be studied and treated individually. Activated carbon is one of the most effective agents now in use for the control of tastes.

Ice difficulties are not very frequent and seldom occur if the intake is deep, say over 20 feet. A surface sheet of ice presents no difficulties unless the stream is very shallow and the ice so deep as to obstruct

the inlet. Anchor and frazile ice occur only if the surface is open and these are more troublesome to intakes 10 feet deep or less. If the intake becomes obstructed with ice the usual remedy is to turn the water pressure into the shore end, and reverse the flow.

Water supplies derived from small inland lakes and creeks present many troubles. The problems of their larger sisters are present in concentrated form, so that of all sources of water supply they are the least desirable. The chief difficulty is due to their shallow depth. Warm water, weed growth, inadequacy of supply at times, odors, tastes and contamination, all are common to these waters.

If the topography will permit, impounding works will remedy many of these ills to a considerable extent. Such works provide a depth of water to drown weeds, permit sedimentation, a more adequate supply when needed and a depth of intake that gives cooler water and less ice trouble. Cleaning out shore growths of weeds by dredging is only temporarily beneficial unless the edges can be made deep enough to prevent re-growth. A chain stretched through the pond or stream with each end carried along opposite shores has proved effective where the shape of the pond permits, but of course the treatment must be repeated two or three times per year.

UNDERGROUND SOURCES

Springs as a source of water supply vary greatly. Some municipalities have ample supplies of excellent quality requiring no treatment, such as Orangeville, Colborne and Coldwater. In other places the supply has gradually diminished or become contaminated. While there is no remedy against a diminishing supply and very little opportunity to predict the lifetime of a spring, contamination can be controlled by purchasing and fencing the known water shed and by picking up the spring as close to its head as possible. Those adopting such a source of supply should be prepared to accept chlorination if and when contamination originates outside their area of control. The purchase of plenty of land along with adequate sanitary supervision is urged.

Underdrainage or filter galleries are usually employed to develop shallow underground supplies that lack sufficient head to break out as springs. The most successful filter galleries are at Simcoe, Ont. and will be described in another paper. Infiltration basins along the lake shore have been tried, as a means of obtaining water from the lake with consistently disappointing results.

Underdrainage may extend under several tilled farms. The supply usually fluctuates seasonally and is inadequate during summer. Contamination occurs at times and is most severe during the spring runoff. Marshy tastes sometimes give trouble.

The difficulties of a fluctuating supply can only be ameliorated by metering each service. Contamination can be reduced by purchasing the farms and either reforestration or confining the crops to those not requiring fertilizer and by excluding live stock. Chlorination must be employed. Underdrainage affords a precarious source of water for a municipality.

Surface supplies seldom have difficulties of chemical composition although some spring and river supplies are unpleasantly hard. In the igneous rock areas such as at Huntsville and Burwash, surface waters have to be treated with an alkali to raise the pH before delivery to the system. Practically all surface supplies have to be disinfected or to have equipment in readiness for this treatment.

Well water supply systems have problems all their own, not so great as some supplies but sufficiently serious to require careful study. A well water may be excessively hard, may have objectionable taste, or odor, is sometimes turbid and may carry quantities of fine sand. Sometimes such chemicals as Iron oxides, sulphuretted hydrogen, carbon dioxide, or methane produce problems. Sometimes the well is difficult to build or to maintain due to fine sand, soft, structurally weak rock, gas or water pressure. Some waters, quite suitable for human consumption, act as an electrolite to set up galvanic action between dissimilar metals of the pump. As this is difficult to predict in advance the greatest of care must be taken in writing specifications for the pumping equipment. It is important to observe that hard waters may be good electrolites although we usually think of aggressive or corrosive waters as being soft. Well waters are almost always sterile if ordinary care is exercised in making the well.

Hard well waters in common with hard surface supplies can only be remedied by softening. This is a field that is just beginning to be cultivated. If the hardness is in excess of 500 p.p.m. the cost is excessive and other sources of supply should be investigated. It is not necessary to soften to much less than 100 p.p.m.

Objectionable tastes and odors (usually due to H_2S) may be removed usually by aeration. This can be accomplished by pumping through nozzles, over trays and other devices, by passing through concrete channels with diffuser plates at the bottom or aeration may

be effected under pressure. Examples of these forms of treatment may be seen at Essex, Ontario Hospital at London, and other places.

Other tastes or odors are not common in well waters and each case must be treated individually.

Iron in the form of soluble ferrous oxide if present in excess of 0.3 p.p.m. is very apt to give trouble. It may induce the growth of crenothrix, a slimy organism that tends to clog the water mains and plumbing fixtures. Such waters stain porcelain fixtures and streak white-wear in the laundry. Iron may be removed by aeration (which oxidizes it into the insoluble ferric state) followed by filtration or precipitation. Unless a reservoir is required as a visible supply for fire pumps, pressure filters will usually be found least expensive.

Iron may also be removed by chemical base exchange in conjunction with water softening.

Carbon dioxide in a water may be aggressive and start a reduction process in old watermains. The incrustation on the inner surface is broken down and what is known as red water trouble ensues. The remedy appears to be the introduction of a chemical to neutralize the CO_2 and one to build up a new crust. Very small quantities are required. Caustic soda and sodium silicate are commonly used. This problem does not occur in new mains. It is likely to occur upon changing from one source of supply to another.

CO_2 and CH_4 may, if present in sufficient quantities, cause pumping difficulties and air lift pumping may have to be resorted to.

Problems incident to the making of a water well can only be mastered by skilled men. There are two distinct types of water wells, those terminating in rock and those in the glacial drift. Usually rock wells are easily drilled but occasionally a layer of fragile rock is encountered between hard strata. Occasionally a water well will encounter fissures that communicate with the glacial drift and carry considerable quantities of silt. Sometimes fine sand immediately overlies the rock and makes it important that the casing be driven well into the rock. If the water supply is to be taken from a structurally weak stratum the well may have to be gravelled and screened as described later. If a silted fissure yields the water supply, the well may have to be pumped for months to wash out the silt. Failing this the water may have to be passed through a sedimentation tank or filters.

Wells constructed in the glacial drift derive water from gravel or sand. It is a comparatively simple matter to finish a well in gravel.

A good type of screen is the chief consideration. Everdur Bronze, copper 96 percent, silicon 3 percent, manganese 1 percent should usually be used. No metal will prevent an encrusting water from gradually clogging the screen but this may be held at a minimum by not pumping below the top of the screen.

Successful wells of large capacity may be made in very fine sand. The problem here is to get out the water without also getting sand. Two large diameter casings should be used and fine gravel introduced around the screen while the sand is being taken out. Only men with long experience and the greatest of skill should be entrusted with this work. No well of this type should be accepted from the contractor until he has controlled the fines and positively prevented surface caving. The problem of determining the safe yield of a well is not capable of definite determination. The source of supply may be a storage reservoir with no appreciable rate of replenishment or it may be a reservoir with conduits such as rock fissures connecting to extensive catchment areas, or in the case of wells in the glacial drift, streaks of relatively coarse gravel may serve as conduits. Again, the glacial drift, although fine may be pervious and so extensive as to extend under and communicate with a very large water shed. These wells may require servicing over periods of 5 or 10 years, and this again should be entrusted to skilled water well men.

Servicing will be less frequent if, when the well is constructed, the inner casing is carried to the surface and the annulus between the two casings filled with suitable gravel. To ensure that the gravel will feed down when required, this space should not be less than 6 inches.

During the construction of wells in glacial drift, water under pressure is sometimes encountered. Water may find its way to the surface exterior to the casings and a crater will soon form. In such locations a rotary rig should be used and heavy liquid mud circulated into the hole and out through the drill stem. The density of the liquid can be increased until its specific gravity is high enough to overcome the artesian pressure.

WELL PUMPS

Reference has been made to galvanic destruction of well pumps. There are several forms of well pump, such as air lifts, reciprocating and centrifugal pumps. As space is limited and the deep well turbine (centrifugal) pump is now almost entirely used to the exclusion of all

others, observations will be confined to this type. The well turbine consists of several bowls or stages in series located near the well bottom and connected by an enclosed line shaft, to a vertical motor above ground. In recent years the design has been very much simplified. Usually the shells are cast iron, the shafting cold rolled steel, the impellers, and bearing-bushings are bronze or some other alloy of copper. The piping enclosing the line shaft and for the water eduction pipe is usually steel or wrought iron. Copper bearing steel, red brass or copper pipe is sometimes used and in England cast iron is used. In special instances all bronze pumps have been used but at very great cost. Recently a new alloyed cast iron, known as Niresist has been recommended but so far as is known there is no Canadian experience with this new metal. In Ontario best results have been obtained from pumps made up of the following metals.

Bowls—gray iron
Impellers—zincless phosphor bronze
Bearings—zincless phosphor bronze (copper and tin)
Shafting—stainless steel (15 percent chromium)
Eduction pipe—genuine wrought iron

Water well pumps and sometimes pumps on surface supplies are frequently operated in the smaller municipalities without manual attendance. Problems incident to this custom are largely limited to the design of electrical equipment. The various electrical devices provide for control of the equipment by changes in the water level in the reservoir, standpipe or elevated tank. The pumps are started and stopped, room heating is regulated, operation is interrupted at times of peak load, sand traps are flushed out, remote recording meters are actuated, chemical feeds are controlled and lubrication is automatically handled. With this type of apparatus the altitude regulator should be installed in a frost-proof pit and a condensation-proof case, beneath the tank to be free of pressure surges when the pump is started or stopped or a cushion tank should be installed on the pressure pipe at the pump. On the cushion tank the number of threaded joints exposed to air pressure should be reduced to a minimum. To do this the pipe may be carried down the center of the tank as in a range boiler. Absorption of the air may be avoided by pouring in a gallon of oil, as a membrane between the water and air. If the pressure switch is under the standpipe or elevated tank a cushion is not required but a control wire must run from the pump to the tank, sometimes a distance of several miles. A telephone wire is

quite sufficient. One additional wire must be added if a remote recording meter is used. For safety, convenience and low cost all electrical equipment except the motor itself, may be assembled as a unit in and on a steel cabinet.

Electrical control equipment so designed solves the problem of cost of manual supervision quite satisfactorily and automatic off peak operation makes the power bill only a book-keeping entry as between the water works and electric departments with no actual money being paid out.

While water wells and well waters have problems all their own, it is not intended to give the impression that such systems are inherently troublesome. Most well systems that have been carefully built are conspicuously free of operating or maintenance problems.

The construction and maintenance of the distribution system in a small municipality offers fewer problems than the water supply.

DISTRIBUTION SYSTEMS

In the design of distribution systems, pipes should be of ample size and equipped with sufficient valves to meet any emergency. There seems to be relatively little use for 4-inch pipe and the cost of 6-inch pipe is only slightly more. The loss of head through 4-inch pipe is too great to leave suitable pressure to a hydrant, and a four-inch pipe is unnecessarily large if used for domestic service only. Considering their usefulness in case of emergency a valve is the cheapest thing you can buy. Ample valve provision should not cost more than one per-cent of the total cost of a water works system. Dead ends are sometimes difficult to avoid and are objectionable from an operating standpoint. Sometimes it will be found economical to join two dead ends, although there are no consumers en route. This is because remote hydrants can thus be served by two pipes and the size of each made smaller. Every water distribution system should be served through a master meter of the integrating and recording type. It is just as necessary as the cash register to the grocer or the clinical thermometer to the physician.

Bell and spigot cast iron pipe is the recognized material for pipe lines, copper service pipe is generally used and the standpipe or elevated tank is nearly always built of steel.

Excavation for installation of the system may present problems because of the previously constructed pavements and sidewalks

occupying most of the street width. On one system recently constructed a main was laid on each side, in the two-foot strip between sidewalk and pavement. Services were installed beneath a 10-foot sidewalk without injury thereto by operating a pneumatic drill from within the store basements. Horizontal holes were drilled through the 24-inch stone foundation walls and under the sidewalks to the watermain trench. Copper service pipe was then threaded through the hole and fitted up on each end. The labor cost per service was $3.00 and the contractor declared he made a profit.

Most distribution systems have a stream to cross some place in their area. The crossing may be made either by laying the main in the bed of the stream with the use of semi-flexible joints or by suspending it beneath a bridge. A convenient and very effective way to prevent freezing of suspended mains consists of a corrugated culvert pipe jacket with the space between the two pipes filled with ground cork. In the fall of 1933 a 6-inch main was installed in Tillsonburg in this way using 5 inches of cork. This main was used for fire protection only, with no velocity except when a hydrant was opened.

During the severe winter of 1933–34 with temperatures of 20 degrees below the main crossing did not freeze.

STORAGE

The selection of the most desirable type of storage should be treated as an individual problem. Water may be stored in surface-level or underground reservoirs, in standpipes or elevated tanks. Some of the older surface reservoirs are in reality artificial lakes. All reservoirs should be covered to prevent algal growths and tastes. The water will be somewhat cooler if about two feet of soil covers the roof. Such reservoirs must be built of concrete. They are useful as a visible supply to fire pumps and as a reserve in case of breakdowns or short peak demands in excess of the capacity of the supply works. The topography seldom permits such a reservoir to deliver water by gravity to the consumers. For that reason they must be supplemented by a comparatively small elevated tank. Where funds are limited it will often be found less expensive to construct a larger elevated tank only, and locate it close to the pumphouse so that it can be switched over to the suction side of fire pumps.

A standpipe has the advantage of large capacity at low cost. If it can be located on an elevation pressures may be satisfactory when

only partly full. If the standpipe is not on high ground water stored in its lower half is useful only as a supply to fire pumps, or to fire trucks, equipped with a booster pump.

Maintenance of a distribution system gives such problems as keeping records of underground construction accurately up to date, painting hydrants, buildings and water tanks, thawing services in winter etc. No underground construction, however small, should be carried out without making uniform and permanent record of the size, location, material used and other particulars.

Hydrants should be kept brightly painted to preserve them from rust, make them easily found by firemen and so that they will enhance the appearance rather than disfigure the street. A conspicuous color will be in contrast with the green grass in summer and also the white snow in winter.

PAINTS

Painting of water tanks should be given more thought than it has usually received. Too often it is limited to exterior painting only. Before paint is applied the metal should be thoroughly cleaned by scraping, steel brushing, buffing or sand blasting.

Paints on the market and claims as to their efficacy are legion. Different waters act differently on paints and steel.

At Aylmer, the wall of a standpipe was badly pitted and the floor in good condition. At Tillsonburg, 15 miles away, the opposite results occurred. Both waters came from farm under-drains and filter galleries. When a soft deep well supply at Aylmer was turned in the paint was still effective after 5 years. At Glencoe, a soft deep well water cuts off the paint and leaves the metal bright and good. (After 7 years service the deep well pumps were found clean and in good condition in the Glencoe wells.)

It is the writer's opinion that special paints should be used with discretion. Good results have been obtained by priming with two coats of red lead followed by two coats of aluminum, for the exterior and two coats of water emulsion asphalt on the inside. The joint between the steel tank and the concrete foundation should be always kept water tight.

OPERATION AND REHABILITATION

Sometimes maintenance of an old system involves steps to increase the capacity. The source of supply may be adequate but the pump capacity may have become insufficient. While to the operator in a

small town, the remedy for this problem may seem to be the purchase of another pump "just like our old one" the solution is not nearly so simple as that, and generally requires the services of a consultant. On several occasions the writer has found abortive attempts to solve this problem. A duplicate pump is installed only to find that with the increased rate of pumpage the existing watermain is far too small and the loss of pressure due to the greatly increased friction head makes it impossible to fill the elevated tank.

Thawing water services is a problem that has been discussed frequently. The most effective means seems to be the use of low voltage high ampere electric current. Manufacturers of electrical equipment now make suitable transformers that can be bought for around two hundred dollars and every superintendent who has this problem, should have one.

After a water works plant has been in service for many years, obsolescence takes its toll. Old steam boilers, inefficient pumps awkwardly arranged and manually operated equipment all add to the cost of operation and frequently to the anxiety of those in charge. Although such plants may produce sufficient water of good quality the cost is high and there is no factor of safety. The obvious remedy for these problems is to scrap the obsolescent part of the plant and install modern efficient equipment. On several occasions it has been shown by actual experience that this can be done and financed with the savings, as at Aylmer, Collingwood and other places.

In the design of new systems or rehabilitation of old ones very material economies are possible by using various devices that are the product of the ingenuity of experienced operators or the laboratories of manufacturers. At Burlington grit in the water is prevented from cutting out the pump packing by a simple home-made sand trap, at Forest the oiler on an air compressor is kept warm by an electric stove element wound around the glass cup, at Etobicoke deep well pumps are automatically oiled by a tiny hydraulic cylinder opening a needle valve when the pump is operating; at Tillsonburg the same thing is accomplished with a solenoid, at Port Stanley a signal light is flashed when the elevated tank fills and a zinc strip grounds a wire going to the pumphouse, and the current to the alum feeder is connected to the floatswitch that operates the low lift pumps.

Dozens of these inexpensive devices are available to reduce the need of attendance and cost of operation. They are particularly suitable for systems having wells as a source of supply.

If the house over a well pump is made small, say 12 feet square, the windows small, the walls and ceiling insulated, it may be heated electrically at very little cost. A time switch interrupts current to the pump motor and room heater during periods of peak load on the electrical power system. A relay with one contractor normally off and one normally on, alternately turns on the pump or the heater so that the heater is not billed as connected load and in many towns costs only .40 cents per hour for a two kilowatt 550 volt heater. If the pump runs half time, this amounts to about 5 cents per day.

Completely automatic systems are being built that operate so well that the water works department's only employee can take time off to attend this convention.

In the municipalities where a surface supply demands more attention the engineer who designs the plant should be required to assume charge of operation for a period of one or two years. It should be his duty to train the operating personnel whose tenure of office ought to be assured that the town may reap the benefit accruing from the cost of their training. Legislation might well be enacted that would ensure continuity of services of trained operators with the same security now afforded the local medical officer of health.

Waterworks officials in the smaller municipalities, whether elected or appointed, should not for one moment fear a loss of prestige when they ask authority to engage competent advice in the solution of problems that are beyond their scope.

(Presented before the Canadian Section meeting, April 1, 1936.)

SOME PROBLEMS OF A WATERWORKS PLANT IN A SMALL MUNICIPALITY

By W. D. Stalker

(Manager, Public Utilities, Town of Simcoe, Ontario, Can.)

The Town of Simcoe is a municipality of 5500 people, situated in sunny southwestern Ontario. It is a well balanced economic unit, being the county town of Norfolk, a shire noted for its greatly diversified agriculture. In addition to those factories closely related to or processing farm products such as canning and can-making plants, dairies, creameries, and cold-storages and those manufacturing jams, pickles, soups and milk products, Simcoe has important textile industries making woolen goods, wool stock and knitted wear, and also a mitt and glove factory doing a considerable export trade. Municipal operations both of its utilities and general town affairs have in recent years invariably resulted in surpluses, and the bonded debt as well as the tax-rate is being steadily reduced.

Its municipally-owned waterworks was installed in 1907 and while this plant has been extended and improved as the town developed and a market for water increased, the original source of water is still the main supply and the original engines and pumps have continued to be operated efficiently and economically.

The unique features of this water supply and the pumping methods used together with the problems they have presented is the subject of this paper.

WATER SUPPLY

Water is obtained by means of a filter gallery located about one half mile west of the town itself, the site selected for this purpose being a flat, lying between a rather low hill on the south and a small stream, known as Kent's Creek on the north. Before making a decision considerable exploratory work was carried out by sinking test holes along the banks of Kent's Creek which flows easterly through a considerable natural drainage area. Just downstream (i.e., east) from the site finally selected, a hard-pan or shale formation running approximately north and south was encountered, and which appears

to hold back to some extent the ground water in the area immediately west causing a rise in the ground water level. This was the final factor in deciding upon the location of the water supply works.

At the time of the original construction the flat selected for the site of the filter galleries was fairly well covered with a substantial stand of cedar trees, and an actual purchase of the land was not made, the owner simply granting a lease for a dollar per year. Subsequently, however, the tree growth was cut off and as the land was being used for pasturage, an irregular shaped plot of four acres containing the galleries was purchased and fenced. The ground in the enclosed area has since become quite well sodded.

At the present time some thought is being given to the acquisition of considerably more land, it being felt that this should be done with a view to reforesting the adjacent area as a water conservation measure and also to preserve and keep uncontaminated at least the immediate part of the natural drainage basin.

To construct the original filter-gallery, excavation was made through the top soil and underlying sandy gravel and a line of perforated tile was laid, at an average depth of about ten feet, first westerly and thence southerly in the flat between the stream and the hill. This conduit is 15 inches in diameter and is ordinary vitrified pipe in sections two feet long. There are longitudinal oblong slots 2 inches long by $\frac{1}{4}$-inch wide in the upper half of the tile, there being four slots in each length of pipe in nine staggered rows 3 inches circumferentially apart. The unperforated or solid half of the pipe is laid to the bottom.

This conduit was laid with open joints and was covered with 16 inches of well rounded and screened natural gravel in size 2 inches down to $\frac{3}{4}$ inch before backfilling with the excavated material.

A number of manholes were also installed, these being built of brick laid in circular or well fashion with only the top 6 feet cemented, this latter of course to prevent the entry of surface water. There is considerable infiltration of water through the lower brickwork into these wells and on later construction the size toward the bottom was increased giving not only larger collecting area but also much better accessibility to the tile for cleaning. The tops of the manholes extend about two feet above the ground level and are equipped with close-fitting bolted cast iron covers.

Ground water with a temperature of about 46° Fahrenheit enters the gallery through the slots in the tile and through the lower brick-

work of the manhole wells. It then flows by gravity through a 15-inch cast iron pipe north-easterly across under the bed of the creek to a sump-well located under the pumping station which is situated on the north side of the stream. The land for the pump house and operator's residence was purchased for this purpose at the time of the original installation, and lies between the creek and a roadway. The soil formation here is different and no ground water is available on this side of the stream.

As water consumption increased the need for augmenting the supply was met by simply extending the weeping tile or collecting galleries. Four extensions have been so constructed at different times and it is now believed that practically all the available water is being collected.

Additional water has therefore since been secured by gravel wall wells at two other locations.

The first of these is about a quarter of a mile southerly and is alongside the system's standpipe which is located in the highest part of the section, the base being 70 feet above the level of the infiltration basin. The operation of this unit is controlled automatically by the level of the water in this tank. The other gravel wall well is a half mile north-easterly and is located in the north part of the town. The water secured here however contains an objectionable amount of iron in solution and a treatment plant to remove it by aeration and base exchange is therefore being installed. The water delivered from this unit will thus be partially softened, the proportion treated by the two methods being such that the hardness will be reduced to about one hundred parts per million. It may be of interest to note also that the treatment in this plant including the aeration will be under pressure and no re-pumping will be done. Operation will also be automatic.

The original filter gallery remains however the system's largest and most economical source of a very satisfactory water.

Some difficulty has been experienced from sand and roots entering the tiles but this has been taken care of, with one exception, by periodic cleaning with the usual sectional rods, ropes, and cleaning tools. Two years ago the capacity of the system was found to be reduced, following a very heavy draw, and the section causing the trouble was located by checking the water levels in the manholes. All efforts to clear a blockage near a large elm tree having failed, an excavation was made, these tile found to be plugged with roots, re-

placed, and covered with fresh stone before refilling. This trouble no doubt arose due to failure to keep the galleries clear and more frequent cleaning was plainly indicated.

It is rather interesting to note that, although the water in Kent Creek is at times contaminated, caused no doubt by run-off from nearby pastures and tilled fields, tests of water samples taken from test holes in the water supply-plain immediately adjacent have invariably upon bacteriological examination been classed "A".

However, a somewhat peculiar problem arose in making an extension in the south-east corner of the supply-area. In excavating for a manhole at the end of a gallery run in a southerly direction, a hard-pan or shale formation was encountered just about at the tile grade. About the same time the bacteriological tests of water samples taken at this point were unsatisfactory, due presumably to surface run-off from the hill which was not so steep in this part and was under cultivation. It was decided to break through the shale, and, fortunately water came up from underneath and flowed up out of a short pipe driven into the hard-pan. An inward sloping concrete structure was accordingly built up from the shale which was twelve feet below ground level; the bottom inside the "well" so constructed was broken-out; and a solid tile run northerly from this "well" to the next adjacent manhole. The net result was a clear cold supply of about 150 gallons per minute which was a very welcome addition to the system.

At the time of the original installation an inlet was constructed in Kent's Creek near the intake conduit, and another supply line run to the pumping station; the idea being that in case of an emergent demand for additional water, as for instance to fight a serious fire, water could be obtained directly from the stream. This need has however not arisen and the use of water from Kent Creek would entail chlorination which has not so far been necessary with the ground water supplies of the Simcoe System.

CEDAR STREET PUMPING STATION

As previously stated a site for the pumping station and operator's residence was acquired on the north side of the creek at the time of the original construction. The pump house was located just across the stream from the filter gallery and the operator's residence was later built a short distance north being close to the public highway.

The pumping station is a substantial solid brick building and has deteriorated but little during the 29 years since its erection. The major expense has been the roof which was covered with slates, these having required considerable replacement. One reason assigned to this is the vibration due to the operation of the reciprocating pumps and engines. On the roof of the pump house planned for the deep well pump and treatment plant it is proposed to use heavy asphalt shingles.

The appearance of the original pumping station is fairly good, but the situating of the operator's residence in front has to some extent marred the general effect. Some improvements to the grounds have been made in recent years, but much remains that might be done. The location, with the small stream on the south and east, has considerable possibilities for real beautification, the grounds being fairly extensive. Judging from a somewhat limited observation of a number of small waterworks plants in neighboring states, our American cousins have given more thought than we in Ontario to the architecture and landscaping of waterworks buildings and grounds and it is suggested parenthetically that we in the smaller municipalities in Canada might do well to remember that "the water customer often judges the quality of our product by the appearance of the pumping station."

The amount of water pumped into the System in Simcoe at each station is metered and is recorded daily. Practically all water sold is also metered, there being only 27 flat rates in the 1615 services supplied.

The total amount of water pumped last year was just under 140,000,000 imperial gallons which averaged 383,000 gallons per day or 72 gallons per capita.

The total amount actually consumed was just over 114,000,000 gallons, averaging 313,000 gallons per day or 59 gallons per capita.

The maximum amount pumped on any one day in 1935 was on Monday September 2, when a little over 590,000 gallons was recorded, and the minimum was on Sunday February 3, with just over 70,000 gallons. The total installed pumping capacity is at present a little over two million gallons per day, which will be increased on completion of the second gravel wall well and treatment plant to two and one-half million.

Of the water pumped into the system during the year just over

82 percent was actually resold through meters, leaving 18 percent used through hydrants, private fire lines etc., and otherwise unaccounted for.

The direct cost of pumping water comprises electrical energy, fuel (in Simcoe's case natural gas), operating wages, and repairs and supplies for the pumping equipment and pumping stations. On this basis water is delivered *into* the Simcoe System *at* the pumping station for 4¼ cents per 1,000 imperial gallons.

This is 57 percent of the operation and maintenance costs of the system which are made up as follows:

	percent
Pumping	57
Distribution	10
Meter maintenance	8
Administration	25
Total	100

In the above cost figures no mention has been made of debt charges or of reserves for depreciation and contingencies. These factors apply to the Simcoe System and are provided for in its rate structure, but as Kipling says that is another story.

The original pumps which are still in use and delivering their original rated capacity are two triplex plunger pumps each having three pistons of ten inch diameter and ten inch stroke. They are double geared and the speed reduction is such that a speed of three hundred revolutions per minute on the driving shaft results in forty strokes per minute. Shortly after installation the plungers or pistons were fitted with bronze sleeves and the tool marks still visible on them are an indication of the minimum amount of wear occasioned in over twenty-five years practically daily operation.

These pumps are driven by two vertical natural gas engines, whose normal crank-shaft speed is three hundred revolutions per minute, one being a two cylinder rated at fifty horsepower and the other a three cylinder rated at 80 horsepower. The four units are installed in line, an engine being at each end and all are connected by clutches, the arrangement being such that the three cylinder engine may be used to drive both pumps; or by sliding the driving pinions of the pumps along the drive shaft by controlling levers, either engine may be used to operate either pump. Normal use however is that each

engine regularly operates the pump adjacent to it. The gas engines are started by compressed air with the usual auxiliary apparatus.

These pumps and engines were considered adequate until 1917, when due to a decrease in gas main pressure during severe weather the dependability and adequacy of the natural gas supply for the engines was questioned. Accordingly a 50 horsepower electric motor was installed as an emergency unit, this being located centrally alongside the pumps and connected by means of a clutch and gearing so that it could be used to operate either of them.

In 1924 a small two-stage centrifugal pump with a capacity of 200 g.p.m. was installed, this being direct connected to a 20 HP electric motor. The purpose of this unit was to maintain a full standpipe throughout the night when the use of water was not such as to require the operation of a larger pump, but had grown to a point where the level of water in the standpipe might be rather low in the early hours of the morning without any night pumping. This condition is now taken care of by the automatically controlled deep well supply adjacent to the standpipe and to which reference has previously been made. The two-stage centrifugal pump is however used as required to augment the deep well supply at the standpipe during days of small consumption, such as winter sundays and holidays.

The original engines and pumps are nevertheless in practically daily use, being called upon to pump the greater part of the water supplied during the busy summer season, and to take the place of the motor driven units which are shut down during the times of the daily hydro-electric power peaks in order to relieve the Electrical Department of the Public Utilities of a motor load which might otherwise add to their cost of electrical power, this being purchased from the Hydro-Electric Power Commission of Ontario on a maximum monthly demand basis.

In case of a fire the operator at this original plant, known as the Cedar Street pumping station, is notified by telephone and a gas engine is immediately started if one is not already in operation. He then stands by to increase pressure if required, and may on the direct instructions of the Chief of the Fire Department cut the standpipe from the system by hydraulic control and pump directly into the mains raising his pressure at the pump house from 60 to 120 pounds per square inch. The normal speed of the three cylinder engine may

be increased if necessary for this purpose. Relief valves are installed on the discharge side of the pumps and on an increase of pressure beyond their manually controlled setting, water is returned directly to the sump well.

There are two force mains connecting this pumping station with the system, the original line running easterly to the municipality and the other, installed in 1929, running southerly and connecting into the system at a point near the standpipe, this being also located immediately west of the town but a quarter mile south of the Cedar Street pumping station. A cross-connection between these two mains at a point close to the Cedar Street plant is normally open but may be closed off and pumping carried on through either line. This was particularly useful in 1930 when, following a change in road grade, due to permanent construction, it was necessary to re-lay a part of the original line moving it into the boulevard to get safe cold weather coverage.

Ordinarily however water from the Cedar Street pumps divides, about two-thirds going directly to the municipality through the original line and the remaining one-third going to the system nearer the standpipe. Installation of this latter line reduced the normal pumping head at the Cedar Street pumping station about six pounds.

One other point, which is perhaps worth mentioning, is that the operation of the natural gas engines helps very materially in heating the Cedar Street pump house during the winter months, and so reduces the fuel bill for this station.

In this brief description of a part of the Simcoe Waterworks, an attempt has been made to show how a system may sometimes be extended and improved to take care of increasing demands at a minimum of capital expense, and also how adequate maintenance may prolong the efficient life of the plant.

(*Presented before the Canadian Section meeting, April 1, 1936.*)

WATERWORKS PROBLEMS OF A SMALL MUNICIPALITY

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(Superintendent, Hydro Electric and Waterworks Department, Port Stanley, Ontario, Can.)

This paper will not discuss any of the many problems except those of source of supply, water treatment for purification and pumping equipment.

Perhaps those of you who live inland will wonder why supply problems arise to those whose source is one of the Great Lakes. About all that may be said in favor of this supply is that the water is wet and of abundant quantity. The quality and potability of water received and delivered is the problem. True, there is plenty of water near at hand, but a lake full of apparently clear water may have its border changed to a strip of brown, turbid water of a width of three miles in half an hour. Wind and weather conditions are the cause of this sudden change, especially in Lake Erie, as it is so shallow and easily disturbed. Large systems with their financial backing, and up-to-date equipment can readily cope with such an emergency, but difficulties arise for the small system with little money to spend.

SOURCE

Previous to 1912, Port Stanley, like many other municipalities, was faced with the acute problems of danger of disease epidemic, fire hazards, and lack of private supplies. Construction of its system was begun in 1912, and the financial resources were limited and considerable "chiselling" had to be done to keep within estimates. The system, due to its lay-out, and large area to be covered, does not lent itself to flexible operation and good pressure regulation. These are all reflected in annual operating cost. Much of the equipment installed did not outlive the debenture period, and depreciation became a big annual item. Naturally Lake Erie was chosen as the source of supply.

The pumping station is situated on a sand shore of the lake which makes an excellent bathing beach that presents a problem from a

health stand-point. This fine, shifting sand changes to coarser sands and finally gravel at a depth of fifteen feet, where clay is encountered.

The original supply works consisted of a rectangular concrete caisson 20 by 25 feet in area, sunk through the sand to the clay or near it, by means of a knife edge on the bottom of the caisson. The walls at the top of the knife edge were perforated with 3-inch tile on a 9-inch spacing, through which water filtered into the caisson. The result was pure, clear water, but very hard. Lake Erie water is noted for its hardness. No effort was made to remedy this difficulty. The pump-house was erected on this caisson, which became the pump well and the clear water well. For a time after the first well was erected no treatment of any kind was required, and an excellent water supply seemed assured. After a few years, however, Port Stanley became a popular summer resort with many cottages, amusement parks, restaurants, and refreshment booths, with the consequence of heavy increase in demand for water. Receding lake levels and heavy silting of gravel in the immediate vicinity of the well perforations made it possible to obtain sufficient water. In 1922 a second well, similar to the first, was constructed, and finally in 1929 a series of five caissons of varying dimensions were completed. The result was as unsatisfactory as before, or even more so, because it seemed that as each well was sunk the sand bar or shore line extended out with it by wind action much as it does at breakwaters, etc. Lake Erie, being of shallow depth is easily stirred up by the slightest storm, which would not disturb the other lakes. The water becomes very turbid and agitated.

About 1922 a home-made chlorinating plant was installed. It consisted of a small concrete chamber, in which was mixed hypochlorite of lime with water, and the liquid fed to the suction line of the pump. This solved the problem for a time, but was not satisfactory because of difficulty of regulation and also lime sediment reached the distribution system, attacking wrought iron pipes of the system.

Until 1928 the pumping equipment consisted of one 50 H.P. Mather and Platt, 20,000 G.P.H. pump and one 6000 G.P.H. Gould Triplex plunger pump. The big pump especially created unfavorable power conditions. In 1928 it was replaced by a 10,000 G.P.H. Moore centrifugal pump powered by a 15 H.P. 220 volt, 3 phase Westinghouse line-start motor. This pump is still giving excellent service when operated alone. In 1931 the Triplex pump was replaced

by a 15,000 G.P.H. Babcock-Wilcox, Goldie-McCulloch centrifugal pump operated by a 25 H.P. 220 volt, 3 phase Westinghouse line-start motor, and a 35 H.P. Hercules gas engine with a 500 gallon fuel storage tank for emergency purposes. Here considerable difficulty arose because of variation in characteristic curves of the two pumps. The small pump cuts out of service at 168 feet head, while the larger one has a head of 205 feet.

In 1928 upon a mandatory order from the Provincial Board of Health, a Wallace and Tiernan suction type chlorinator was installed. This solved our chlorinating problems after we became familiar with the construction and operation. It has paid good dividends upon the cost price in saving of operation over the old system, besides assuring safe water for our consumers and relieving the operator of anxiety and worry.

In 1932 a second 66,000 gallon elevated tank was installed on a hill approximately one and one half miles from the pumping station at the same elevation as the first tank installed in 1912. The first is situated about 600 feet from the pumping station. The construction of the second tank partly solved problems of pressure regulation in the district about two miles east of pumping station, besides giving increased storage facilities and more advantageous use of power consumption by permitting pumping at off peak periods.

In 1933 it was decided to lay an intake into the lake. An 8-inch pipe was extended about 150 feet into about 4 feet of water. This was constructed in winter on the ice and lowered by cutting a channel, the action of the wind covering it. On the end was installed an elbow turned upward with a screen cylinder about 14 inches long and 10 inches in diameter covered with ¼-inch iron plate 24 inches square. This pipe lead directly to the outer caisson or well and was controlled by a gate valve inside the well.

TREATMENT

At the same time two large pressure filters were installed and considerable change in pumphouse pipe layout was made, to lend itself to the operation of these filters. A Venturi tube was inserted in the filter influent and an alum pot for the introduction of alum. The intake proved troublesome due to its short length and high rate of flow. First it was not out far enough to avoid bathers. It collected debris and mud in summer and was completely frozen over in winter, shutting off the water supply. The filters clogged because

of an excessive overload of mud. Too much backwashing was required, thus diminishing amount of water delivered to the distribution system. A very low consumption of alum indicated that the Venturi tube was not effective in diverting sufficient flow through the alum. Due to the water being taken too close to shore it was of high temperature thereby increasing waste because more was drawn off at taps in house and other places of consumption in an attempt to get cool water.

IMPROVEMENTS

With all these problems still unsolved the citizens voted $20,000 in 1935 to improve pumping and purifying plants and install a proper intake. A 12-inch cast iron intake was laid 1600 feet into the lake, terminating in 20 feet of water. Four of the old infiltration wells were converted into settling basins. Part of the well under the pump house was appropriated for a settled water well and part for low lift pump well and intake entrance. In a space in each of the first and second wells was constructed a battery of vertical flow coagulating tanks. Powdered alum is fed into the low lift well at the intake entrance by an Omega dry feeder. Low lift pumps in duplicate are of the vertical centrifugal type. The wells from which they pump is separated from the intake entrance by a bronze screen, 3 feet by 4 feet and of quarter inch mesh.

Comparatively cool water, free from excessive contamination but still subject to turbidity at times, is pumped through the mixers and settling tanks into the settled water or high lift pump well. From here it is forced through pressure filters to the distribution system. Many of our old problems have been solved and some new ones presented. Ice, débris and warm water are a thing of the past, but sudden turbidity is still a problem that requires an attendant on duty at all hours of operation. As this is being written we are having an experience to verify this statement. Kettle Creek empties into Lake Erie at Port Stanley. Due to heavy ice from 14 to 20 inches thickness being in the lake as far as can be seen, the flood water from above mentioned creek spread out over the intake and turbid water was noticed immediately at the pumping station. Quick action had to be taken to correct the trouble. It took a few days experimenting to find correct amount of alum before water came clear from the filters. Of course this amount will vary according to turbidity. At present

the rate of alum feed appears to be about two and a half grains per gallon of water pumped. This is based on the name plate rating of the pump. There is no other method installed at present to measure volume of water pumped.

With the new plant, not only annual debenture payments are increased, but operating costs as well, due to constant attention. Formerly, when operating with the old natural infiltration system, it was only necessary for public utilities service men to visit the plant at most every two hours, or in case of power failure. An attempt is being made to reduce this cost by having a man capable of other work, such as meter inspection and repairs, on duty. The management operates two utilities, the electric distribution system as well as the waterworks system. The operating cost may be reduced by coördinating some work of each, assigned to the one capable employee.

DISTRIBUTION

Our distribution system covers an area of approximately three and a half square miles. The greatest distance from the pumping station to the extreme east end is two miles, one mile west and one mile north.

Service is given to 600 domestic consumers, 75 commercial and one industrial, an ice plant that demands about 30,000 gallons per day during summer months, also a swimming pool demanding 100,000 gallons every night during June, July and August. Our maximum daily demand is seven times the average daily demand throughout the year, and ten times the minimum daily demand. It can be seen that the heavy capital outlay is required to give service over such a wide area with few services from which to collect revenue.

Summer resort residents apparently are not noted for neighborliness. They like to live far apart, thus increasing cost of serving them with both utilities. They, as well as the permanent population, are particular about the quality of the service rendered them. They are used to good service and a supply of safe water in the cities from which they come. They become anxious and sometimes move out if the water supply becomes disturbed or in any way dangerous. Evidently their home M. O. H. has been warning them to be careful of water supply in summer resorts.

Our population varies from 4000 in summer (some days and weekends to 20,000) to about 800 in the winter time, when everything

tends to freeze up, even the water distribution system, and the storage tanks, as has been the case this past winter. Considerable water is lost and wasted in attempts to keep the water running.

No doubt these problems are characteristic of municipalities situated on the Great Lakes and the remedies adopted in our case should be found effective elsewhere.

(*Presented before the Canadian Section meeting, April 1, 1936.*)

A PITOMETER WATER WASTE SURVEY IN LACHINE, QUEBEC

By Robert Dorion

(*City Engineer, Lachine, Quebec, Can.*)

The City of Lachine is situated ten miles west of Montreal, and has a population of 19,000.

The water system was constructed in 1889, at which time, water was pumped directly from the St. Lawrence River to the water mains.

In 1932, a filtration plant and new pumping station were erected and the old pumping station was discontinued. The total water consumption of the City is measured by a 20-inch by 10-inch Venturi meter. Water is filtered and chlorinated at the filtration plant. Eight rapid sand filters provide a capacity of 8,000,000 gallons per day.

The water distribution system has a total range of 33.2 miles of main varying from 4 to 20 inches in diameter.

There are no tanks or reservoirs. All industrial plants are metered for commercial use, the fire lines are also generally metered and about 10 per cent of domestic consumers are metered.

After the very cold winter of 1933–1934, where many water mains and house connections were frozen, the water consumption increased every month until the New Station was pumping at full capacity, reaching a peak of over 7,000,000 gallons per day. Emergency repairs were done, but still the water consumption was about 5,000,000 gallons per day. A pitometer survey was then decided on and a contract was awarded to the Pitometer Company of New York.

SCOPE OF THE WORK

1. A test of the pumps and Venturi meter at the pumping station for slip and an accurate measurement of the total consumption of water by the City for a period of twenty-four hours.

2. Division of the water system into five districts and a measurement of the water consumption in each district for a period of twenty-four hours.

3. Further investigation in all districts where excessive waste was indicated by the Pitometer for the purpose of locating all underground leaks in the mains and service pipes.

4. Test for accuracy of all meters larger than 3 inches in size in place, under normal condition without removal; also test of large consumers for the purpose of detecting illegal use through fire lines or otherwise.

5. The preparation of a map of the distribution system showing the location of all Pitometer gauging points, district boundaries, etc.

In the first place, the filtration plant and pumping station being new, none of these pump test results showed indications of mechanical defects in the pumping units; also the test of the Venturi meter, having a difference of two per cent with the Pitometer, was therefore found correct.

A twenty-four hour Pitometer measurement of the total consumption of the City was made on the 20-inch main supply in the filtration plant with the following results:

Total consumption	3,865,000 gallons per day
Maximum rate	4,450,000 gallons per day
Minimum night rate	3,170,000 gallons per day
Ratio minimum night rate to total	82 percent

DISTRICT MEASUREMENTS

The City was divided into five districts and the consumption in each district was measured for a period of twenty-four hours. Charts showing the variation of consumption in each district was produced.

District No. 1 comprised a residential area including the Lachine High School. In that No. 1 district, the leakage located amounted to 390,000 gallons per day.

District No. 2 comprised industrial plant tenements and two schools. In No. 2 district, the leakage located was 342,000 gallons per day.

District No. 3 was a sparsely settled residential area, including two schools and the Dominion Engineering Works Co., Limited. Leakage located was 363,000 gallons per day.

District No. 4 was the main mercantile area of the City and several industrial plants of which one was the Dominion Bridge Co., Limited. It also supplied the Town of Lasalle, contiguous to the City of

Lachine, and is metered. That No. 4 district showed a leakage of 867,000 gallons per day, which is caused by the density of population in a limited area.

District No. 5 was a sparsely settled residential area, including several small industrial plants. Leakage located was 133,000 gallons per day.

SPECIAL TESTS

Special tests were made in several cases. One on the 20-inch supply main showed a leakage of 40,000 gallons per day.

Special test was also made at the Dominion Bridge Co., Dominion Engineering Works Co., The Steel Co., of Canada Limited, Jenkins Valve Co., and Canadian Allis Chalmers Co., Limited. Those tests have shown many defective fire lines, proving that inspection of same should be done at frequent intervals.

METER TESTS

All industrial meters of 4 inches and over in size, were tested. Two fire lines meters were found stopped.

Forty-eight valves were found leaking when in operation.

Five valves were found closed.

Two valves were found broken.

Eight valves were found with bent sterns.

Two valves were found too stiff to operate.

Six valve boxes were found below grade.

For the six months' period ending January 1, 1935, the average daily consumption was 4,390,000 gallons per day and was distributed as follows:

	gallons per day	*percent*
Metered consumption	363,000	8.3
Under registration industrial meters	40,000	0.9
Underground leakage	1,377,000	31.3
Estimated house waste	746,000	17.0
Estimated public use	88,000	2.0
Total accounted for	2,614,000	59.5
Unavoidable leakage at 3,000 gallons per day per mile of main	100,000	2.3
Unmetered use and waste	1,676,000	38.2
Total consumption	4,390,000	100

UNDERGROUND LEAKAGE

In all, 95 underground leaks were located. Where possible, photographs were taken of the leaks on the main. The different types of leaks are classified as to nature and amount.

Type	Number	Leakage *gallons per day*
Broken main	1	100,000
Joint leaks	15	774,000
Service leaks	66	414,000
Fire hydrant leaks	7	46,000
Valve leaks	3	13,000
Abandoned services	3	30,000
Total	95	1,377,000

Basing cost of production at 2 cents per 1,000 gallons, repairs of these leaks represent an annual saving of $10,052.00.

HOUSE WASTE

In addition to the above leaks, we must add the leakage of house fixtures. The total number of leaking fixtures are classified below:

Faucets	143
Toilets	499
Miscellaneous	43

Total leaking fixtures, 685. Estimated waste, 746,000 gallons per day. Basing cost of production at 2 cents per 1,000 gallons, repairs of these leaking fixtures represent an annual saving of $5,445.80.

The combined total of underground leakage and house waste located, amounted to 2,123,000 gallons per day, and represents an annual preventable loss of $15,497.00, distributed in approximately equal amounts between power and chemicals.

That Pitometer Survey was organized and started in December, 1934, had to be postponed during winter and finished in July, 1934.

Over 1,000,000 gallons per day of leaks has already been stopped. The work was suspended during the winter, 1935 and was carried on the following summer.

The total consumption of water in 1933 was 1,474,861,000 gallons. In 1934, we had 1,718,745,000 gallons; a surplus of 243,884,000 gallons per year. In 1935, after part of repair work was done, the result is actually 1,354,258,000 gallons; a saving of 364,487,000 gallons per year; practically 1,000,000 gallons per day.

Savings thereby effected were: Power, $3,288.87; chemicals, $2,337.08 and labor, $697.83, making a total of $6,323.78.

When repairs on leaks found by the Pitometer Survey will be completed, we shall be able to effect a saving of approximately $15,000.00 per year.

THE SURVEY

In order to facilitate the work of the survey, we divided the City in five districts, owing to its configuration and flow control.

To give you an illustration, let us take district No. 1 as an example. Three mains permit the water to flow to that district; one on Notre-Dame Street, one on Broadway and one on St. Joseph Street. Two were closed, permitting only one water main on Notre-Dame to provide water to the district. The Pitometer was then tapped on that main using a 1-inch corporation cock; photographic registration was made through the pitometer during 24 hours and the total flow of water was obtained for that time.

That gave the maximum and minimum flow of water in that district during 24 hours.

Next, we stopped incoming flow of water on all streets on that district between the hours of 11 P.M. and 5 A.M. and kept on registering on Pitometer, and found through it the total leakage in that district.

For locating those leaks, we found it was to the better advantage of any municipality to have a trained man as so many instruments are used for that purpose like the Aquaphone, the Leakaphone, the Geophone and other electric appliances.

The Pitometer Survey in Lachine has been organized and executed in such a manner that every year, it will be possible to check and control the flow of water in every district. To that effect, fifteen gauges were placed permanently by installing corporation cocks in manholes.

The City has purchased a Cole Pitometer rod and accessories. The operation of the Pitometer and of locating leaks was taught to one of our engineers who is now able to perform all the work concerning same.

After all leaks located by the present Pitometer Survey are repaired, it is our intention to have our Filtration Plant Staff make an annual survey of one district.

CONCLUSIONS

In concluding, I may mention a few recommendations that were made to the City Council of Lachine to prevent loss of water:

1. House inspection to be made at least once a year with a complete and detailed report on each house.

2. Meters to be installed on all services where cellar siphons and ice machines are in operation.

3. Installation of compound meters on every fire line of all manufacturers.

4. All valves to be operated at least once a year and to be maintained in good condition.

(*Presented before the Canadian Section meeting, April 2, 1936.*)

SELECTION OF COAGULANTS

By L. C. Billings

(Superintendent and Chief Chemist, Water Purification Plant, Dallas, Tex.)

Although workers in water purification processes have been using various methods and chemicals for coagulation for over forty years, there is much room for study in determining the best adaptation of methods to the water to be treated. By method not only the kind of coagulant is meant, but the type of mixing, including period of mixing, velocities and periods of quiescence, how to handle the mixed water to sedimentation basin, time elements, secondary treatment with coagulant and chemical condition of water applied to filters.

Of late years designers of large plants have found it feasible to study a source of supply with pilot plants before attempting design. Wherever this is possible such a means of approach has been very useful in producing a satisfactory design. Probably in a majority of cases there is no other phase of water treatment so vital to the production of a suitable finished water as is the coagulation process. Without adequate coagulation the filters cannot function properly in delivering a clear effluent. In fact, our filters are very limited in their range of adaptability to different degrees of agglutination of material passed to them. Along with turbidity many supplies must have satisfactory color removal. Bacterial concentration must be reduced by suitable coagulation. Again the handling of taste and odors is aided greatly by proper coagulation.

This discussion will be limited wholly to the practical side of the subject. If it is desired to obtain information about hypotheses of coagulation, the recent works of the following authors will be helpful: Bartow, Black and Sansburg (1); Black, Rice and Bartow (2); Miller (3); Theriault and Clark (4); also, the many helpful articles by John R. Baylis (5), and others.

It is interesting to know how coagulation is accomplished on different types of water in various sections of the country. The raw water characteristics are usually determining factors in the selection

of types of coagulant, although there are examples where design of treatment plant forces the use of a certain coagulant until the energetic operator can orientate conditions of design by changes such as to give more flexibility in operation. Table 1 indicates some of the variable conditions in raw water and the different methods of application of the coagulation processes.

At Eugene, Oregon (6), a treatment plant of 12 m.g.d. handles the McKenzie River water of 18 p.p.m. total hardness, low average turbidity, no color, and pH of 7.0 to 7.4. In 1933 alum was required only 55 days. Settling basins and filters of conventional design give the water the only treatment other than chlorine for the remainder of the time. The maximum dosage was 1.54 g.p.g. when turbidity was at 400 p.p.m. The optimum pH is 6.6. Apparently enough alum and lime were added to establish this optimum pH for such treatment.

Mechanical mixing gives complete floc formation. Mixed water is distributed to settling basins through a perforated baffle wall (an excellent preventive of floc breaking). This perforated baffle wall has 4-inch diameter holes on 24-inch centers. The settling time is 12 to 16 hours. When the plant reaches its capacity, this time will be 4 hours. The applied water turbidity is less than 10 p.p.m. It would seem that design and coagulant were chosen to meet a comparatively easy problem in coagulation.

At Appleton, Wis. (7), a surface water carrying an average color of 40 p.p.m., maximum 80, and minimum 25, presents the larger problem. Turbidities are, average 28 p.p.m., maximum 100, minimum 8. Carbonate hardness is 139 p.p.m., maximum 157, minimum 118. pH values are from 7.8 to 9.0. Alum alone is used for coagulation, the feed varying between 2.5 and 3.5 grains per gallon. The dosages are said to be high in order to reduce the color from 80 to 12 p.p.m. The pH of the finished water is 7.2. Mixing is accomplished by injection of coagulant into the raw water line before aerators. Apparently no other mixing of any consequence is provided. The detention period in the settling basins is from 9 to 24 hours.

This plant is typical of a case where an operator has used initiative and ingenuity in providing necessary mixing partially to overcome an important omission in design. In line with our coagulation study this might be a possible interesting development if it were possible to make some changes in mixing and settling. A variety

TABLE 1

Showing representative types of water to be coagulated

TABLE 1

Showing representative types of water to be coagulated

	EUGENE, ORE. Year 1933						APPLETON, WIS. Year 1932				BALTIMORE, MD. Year 1932					
	Raw			Finished			Raw			Finished	Raw			Finished		
	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Average	Maximum	Minimum	Average	Maximum	Minimum
Water characteristics:																
Carbonate hardness, p.p.m.	18	—	—	—	—	—	139	157	118	—	37	44	29	40	56	30
Non-carbonate hardness, p.p.m.	—	—	—	—	—	—	—	—	—	—	2.1	4	2	9	18	6
Turbidity, p.p.m.	—	400†	Tr.	—	—	—	28	100	8	—	15.5	70	6	0.18	0.7	0.1
Color, p.p.m.	0	—	—	—	—	—	25	80	40	—	6	25	3	2.5	5	2
pH, p.p.m.	—	7.4	7.0	—	—	—	8.4	9.0	7.8	7.2	7.1	7.5	6.9	7.7	8.8	6.7
Treatment:																
Lime, g.p.g.	*						0	0	0		0.37	1.35	1.0			
Alum, g.p.g.	1.54	—	—				3.0	3.5	2.5		0.70	1.27	0.34			
Ferrous sulphate, g.p.g.	0	0	0				0	0	0		1.63	2.00	1.26			
Chlorinated ferrous sulphate, g.p.g.	0	0	0				0	0	0		0	0	0			

	GRAND RAPIDS, MICH. Year 1934						TOPEKA, KAN. Year 1935–1936		FORT WAYNE, IND. 6 months, January to June 1935						DALLAS, TEXAS Year 1935					
	Raw			Finished			Raw	Finished	Raw			Finished			Raw			Finished		
	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Average	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
Water characteristics:																				
Carbonate hardness, p.p.m.	189	256	124	52	84	30	209	37	172	216	123	29	33	22	113	173	40	34	105	22
Non-carbonate hardness, p.p.m.	60	105	30	68	114	35	45	50	143	159	112	68	79	64	9	56	0	13	90	1
Turbidity, p.p.m.	32	730	5	0	0	0	1874	—	64	123	46	—	—	—	341	3940	34	0	0	0
Color, p.p.m.	17	60	0	3	26	0	—	—	57	75	42	6.6	7.5	5.8	0	0	0	0	0	0
pH, p.p.m.	7.8	8.4	7.0	8.9	9.3	7.9	9.0	9.1	7.6	7.8	7.5	9.2	9.2	9.0	8.1	8.4	7.9	8.9	9.5	8.4
Treatment:																				
Lime, g.p.g.	7.7	10.9	5.9				9.98		10.06	11.70	7.27				4.2	6.3	2.2			
Alum, g.p.g.	0.71	2.94	0.42				1.21		0.79	1.67	0.22				0.60	1.43	0.08	Intermittent use		
Ferrous sulphate, g.p.g.	0	0	0				0		0	0	0				0	0	0			
Chlorinated ferrous sulphate, g.p.g.	0	0	0				0		0	0	0				0.60	1.52	0.15			

* Lime added to make alkalinity. Optimum pH 6.6.
† In 1933 only 55 days treatment needed.

of coagulants could be used along with lime treatment. A softer water for public consumption at reduced cost of operation might be an inducement.

At Baltimore, Md. (8), coagulating problems are not severe, the alkalinity or carbonate hardness being average 37 p.p.m., maximum 44, minimum 29; with low color average 6 p.p.m., maximum 25, minimum 3; pH of 7.1 average, maximum 7.5, minimum 6.9. The design of the plant is well suited to treatment conditions. Alum is used as the coagulant, with lime as a conditioner. The alum feed averages 0.70 g.p.g., maximum 1.27, minimum 0.34; line 0.37 g.p.g., 1.35 maximum, 1.0 minimum. Alum is manufactured on the plant and is applied as a diluted syrup, making coagulation cost low.

Excellent facilities for laboratory research at this plant have developed the proper balance of design and treatment for the work to be done on the water.

At Grand Rapids, Mich. (9), a softening plant handles a carbonate hardness of 189 p.p.m. average, 256 maximum, and 124 minimum. Turbidity is fairly low, 32 p.p.m. average, 730 maximum, 5 minimum. Average pH is 7.8. Excess lime treatment is used which is equivalent to treating a part of the water to excess and mixing with the untreated portion. Precipitation of natural magnesium greatly aids in coagulation. The alum dose averages 0.71 grain, maximum 2.94, minimum 0.42. Mixing consists of round the end baffle system with flexible time period. Pre- and post-chlorination are used. Lime treatment averages 7.7 grains, maximum 10.9, minimum 5.9. At times, all or a portion of water is passed through a clarifier. Coagulation is quite satisfactory except that excess lime must be used in sufficient quantities to precipitate approximately 50 percent of the magnesium. A study of the different types of coagulants with this water might show some advantage of one over the other with respect to economy of treatment.

At Topeka, Kan. (10), the average raw water turbidity is 1875 p.p.m. A carbonate hardness of 209 is treated with 10 grains of lime and 1.2 grains of alum. This is another example where excess lime treatment aids in the coagulation process. A 50 percent reduction in magnesium results (14.2 to 7.3 p.p.m. as magnesium). In all probability the optimum pH for alum coagulation was maintained with a large amount of lime which was primarily used for softening.

At Fort Wayne, Ind. (11), excess lime is again used which is an aid in coagulation in elevating pH to the proper optimum. The

average turbidity of the raw water is only 64 p.p.m., maximum 123, minimum 46. pH average is 7.6 and the finished water 9.2. Recarbonation apparently reduces pH considerably from above 9.2 in the mixing chamber.

At Dallas, Texas (12), lime and iron have been used for a number of years. With the advent of the Bachman Plant, a more varied range of turbidities had to be handled, necessitating large quantities of iron sulphate. These reactions were slow and sluggish at times of high turbidity. The average carbonate hardness of the raw water is 113 p.p.m., maximum 173, minimum 40; average turbidity 341 p.p.m., maximum 3940, minimum 34; pH average 8.1, maximum 8.4, minimum 7.9. The lime treatment applied was 4.2 grains, maximum 6.3, minimum 2.2; iron sulphate chlorinated, average 0.60 grain, maximum 1.52, minimum 0.15. The ratio of chlorine to copperas is close to the theoretical 1 to 7.8. About 50 percent of the time alum is used as a secondary coagulant (0.60 grain). This secondary dose could be eliminated with suitable means of flocculation and suitable settling basin design. At present the original floc is broken by passing through three sets of constricted openings or gates before reaching filters requiring the use of secondary coagulation.

The above examples typify the variety of conditions with which the water purification and filtration engineer has to deal in providing adequate and economical means for the satisfactory production of water. The interesting and impressive fact is that a general formula for the creation of a design or selection of a coagulating system cannot be made to apply in all cases. A thorough analysis of raw water conditions is quite necessary and pilot plant operation of at least a years time is highly desirable when a surface supply is involved.

MIXING

In thinking of coagulation, the first consideration is to get the coagulant to the water in the most effective way which must be by mixing the two intimately enough to start and complete thorough chemical reaction. This mixing must be done quickly and thoroughly and the proper provision made for flocculation. Flexibility of intensity and time are absolutely essential to proper coagulation. Designers have different ways of doing this such as providing baffle chamber sections, mechanical agitation, etc. Too often many fac-

tors such as time and velocity for a wide range of flows, consideration for the maximum degree of coagulation necessary, cognizance of the fact that temperature range from 86° to 35°F. has influence on time of mixing, are often neglected.

In general, a quick rapid mix with a subsidence period is highly desirable, particularly at summer water temperatures. Winter temperatures require more time with slower mixing. This means that for the same flow a winter condition will require from two to three times as much baffled mixing chamber as in summer. Mechanical mixing should be correspondingly adjusted. Such flexibility of mixing can usually be obtained in case of baffle chambers by installing take off gates at quarter way points or at any other fractional division advisable. In case of mechanical mixing, enough units should be installed to take care of maximum conditions and provision made for cutting out units as occasion would demand. Flexibility in this important step of coagulation is usually neglected and there is great need in most plants for careful consideration in design. The cost of this extra equipment is negligible and is saved in a short time in cost of materials for operation.

SETTLING

Following the mixing operation a well formed floc should be handled rather carefully and preferably permitted to be gently circulated through the water by some type of flocculating system in order to make clarification more complete. Continuous removal of sludge is worthwhile, particularly in the case of softening plants. Sludge may be re-pumped to mixing basin provided sludge is suitable in characteristics.

In cases where settling basins are depended upon to settle the floc, the formed floc should be conveyed from settling basins to mixing chambers without too few constricted openings which tend to break up the coagula. These coagulated particles, once formed and broken, are reformed with great difficulty. Often times, large basins without baffles present a problem of short circuiting which could be corrected by construction of a baffle through the center as high as within four or five feet of the surface of the water. Settling period should be divided into primary and secondary sections, with provision for secondary coagulation between the two periods of settling, proper mixing for the coagulant being provided at this point.

SELECTION OF COAGULANT

Next in importance is the selection of the proper coagulant, that is one that will primarily coagulate the particular water in question the best and in the most economical manner. As the problem of coagulation has been studied during the last few years, the fact that certain coagulants will not work equally well on all waters has been well established. In the field of general municipal use are aluminum sulphate, ferrous sulphate and lime, ferric sulphate, ferric chloride, ferrous chloride, chlorinated ferrous sulphate or chlorinated copperas. The cost of these materials are not so widely divergent, but of recent years the limitations of each have been discovered through new found knowledge of their performance. For instance, the application of the ionic measurements in solutions expressed as pH has brought out the fact that aluminum sulphate in waters of an average buffer condition does not work as well above 7 and below 9.5 or 10 as below 7 and above 10; and that at certain pH values the aluminum precipitate is quite soluble. Also, it is possible to find the "optimum" pH at which the aluminum sulphate will work best in a given water. Aluminum sulphate has been found to work at a disadvantage with soft colored waters. Yet with a considerable variety of waters aluminum sulphate has measured up well with satisfactory and economical performance.

Iron salts

Of late, iron salts have been given more attention, particularly the trivalent iron (chlorides and sulphates). These operate well in a wide range of water pH (3 to 13) making them appealing to the water purification profession that has to handle high variable turbidities and highly colored waters. Such iron salts are marketed, some in crystalline form and others as expensive solutions. The salts, particularly sulphates, are soluble with some difficulty and in solution iron salts are often erratic in behavior, changing to more or less inert compounds in so far as coagulation is concerned. To a certain class of waters the use of iron salts have proven not only very desirable coagulants, but they are a valuable asset in the form of low operating cost. The water works man, being attracted to iron salts, very readily observes from experience that he can manufacture his own material at low cost and remove a very serious objection to the use of such salts for coagulation, namely that of low efficiency due

to instability of the iron salts in solution. He finds that he can make ferrous or ferric salts with cheap chlorine and scrap iron; or he can buy a ferrous salt and oxidize it to the more efficient ferric salt by the use of chlorine as he uses the coagulant.

Attention is called to the experience with chlorinated copperas as a coagulant used with lime at Dallas (13). A period of three months has been previously reported. The results were very gratifying, presenting a saving in cost of coagulant and the product of coagulation was very much superior in physical characteristics. The following advantages of chlorinated copperas were evident.

1. Floc formation clean cut and of proper size.
2. Floc particles tough and resistant to breaking up.
3. Rate of settling is influenced by density of suspended material. Large amount of coarse suspension in raw water or a high bicarbonate alkalinity for reaction with lime aids in settling.
4. Floc ordinarily settles well and residual small floc going to filters is distinct and of sufficient volume to load sand beds well without building loss of head unduly.
5. Coagulating effect constant regardless of considerable variation in pH (8 to 9).
6. In handling turbidities around 3,000 p.p.m., 0.5 g.p.g. chlorinated copperas will do the work if pH is elevated above 9.0 with alkalinity showing 5 to 10 p.p.m. caustic.
7. A saving in coagulant costs results. Over a three month period an average saving has been 67.6 cents per million gallons ($10.50 per day) which amounts to a yearly saving of approximately $4,000 at the Dallas plant.

Table 2 indicates 2½ years more of the same experience with the same satisfactory results. The estimated savings as shown by the three months experience was more than realized in the longer period and the plant also maintained the same standard of quality. However, the mixing arrangement at Dallas could be greatly improved in the interest of coagulation. A flocculating system could be installed, thus eliminating a small secondary dose of coagulant at the end of the settling period, thus producing another saving of $2,000.00 per year.

It is worth while to emphasize a statement about the arrangement of the oxidation system with chlorine used at Dallas. Ferrous iron solution is conveyed to the mixing chamber through a lead lined

iron pipe. At the entrance to the mixing chamber a transite pipe of 20 feet length is attached to the end of this feed line. The chlorine solution line enters this transite pipe about 15 feet from the discharge end. The instantaneous oxidizing action makes available at once a very potent and dependable coagulant of ferric sulphate and chloride for immediate use. As other coagulants have their disadvantages, so chlorinated copperas has its disadvantages. In order to have the chlorinated copperas work to the best advantage in small concentrations, either a heavy coarse turbidity or a bicar-

TABLE 2

Showing water characteristics and quantities of chemicals fed at Dallas, Texas

YEAR	TURBIDITY, IN P.P.M.			CARBONATE HARDNESS, P.P.M., AVERAGE	LIME, G.P.G.	IRON, G.P.G.	RATIO OF COPPERAS TO CHLORINE	CHLORINE, P.P.M. FOR		ALUM, G.P.G.
	Maximum	Average	Minimum					Copperas	Filtered water	
1934 yearly average	4870	309	30	127	4.1	0.51	7.5	1.17	0.57	0.57
Average yearly price per pound						0.01145		0.0322		0.0155
1935 yearly average	3940	341	36	113	4.2	0.59	8.7	1.17	0.88	0.58
Average yearly price per pound						0.0128		0.0338		0.0158
1936 6 months average	3000	166	12	149	4.7	0.50	8.3	1.03	0.92	0.29
Average 6 months price per pound						0.013135		0.033		0.0153

bonate alkalinity of at least 100 p.p.m. expressed as calcium carbonate must be present to furnish sufficient specific gravity of coagulum for proper settling. The presence of sufficient alkalinity and lime treatment to reduce alkalinity 60 or 70 percent is necessary for good action of coagulant. It is observed that the elevation of the pH to 10 or 10.5 increases the efficiency of coagulation. With alkalinities below 100 p.p.m. and fine colloidal like turbidities, increased quantity of ferrous sulphate chlorinated must be used, but even under such conditions the ratio of chlorinated copperas with lime to copperas with lime is about 1 to 2.

Table 3 shows rather vividly the savings effected by the substitution of chlorinated copperas and lime for copperas and lime.

In 1934—8,146 m.g. coagulated saving 53 cents per m.g.....	$4,300
In 1935—7,631 m.g. coagulated saving 74 cents per m.g.....	5,600
In 1936, 6 months, 4,299 m.g. coagulated saving 65 cents m.g..	2,800
Total saving in thirty months.....	$12,700

From our experience, mostly from laboratory experiments, we believe that chlorinated copperas will best show its advantages in

TABLE 3

Coagulation costs at Dallas, Texas

YEAR	TURBIDITY	CHEMICAL	AVERAGE, LBS. PER M.G.	AVERAGE UNIT COST PER POUND	AVERAGE COST PER M.G.	TOTAL COAGULATION COSTS PER M.G.
1934	Avg. 309	Ferrous sulphate.....	72.4	$0.01145	$0.83	
	Max. 4870	Chlorine.....	9.65	0.0322	0.31	
	Min. 30	Alum (secondary coagulation used 50% of time).	40.4	0.0155	0.63	$1.77
1935	Avg. 341	Ferrous sulphate.....	83.8	0.0128	1.07	
	Max. 3940	Chlorine.....	9.63	0.0338	0.33	
	Min. 36	Alum (secondary coagulation used 50% of time).	41.1	0.0158	0.65	$2.05
1936	Avg. 166	Ferrous sulphate.....	71.0	0.013135	0.93	
6 mos.	Max. 3000	Chlorine.....	8.55	0.033	0.28	
	Min. 12	Alum (secondary coagulation used 50% of time).	19.9	0.0153	0.30	$1.51
1934	Total unit coagulation costs if lime and ferrous sulphate used ($FeSO_4$ quantity doubled).....					$2.29
1935	Total unit coagulation costs if lime and ferrous sulphate used ($FeSO_4$ quantity doubled).....					$2.79
1936	Total unit coagulation costs if lime and ferrous sulphate used ($FeSO_4$ quantity doubled).....					$2.16

instances where lime is used for softening purposes, thereby assuming that the optimum point for ferric iron coagulation is produced by the lime addition. As to its efficiency in the acid zone, our information is not complete but others have had good results with acid waters containing appreciable quantities of color.

SUMMARY

While coagulation treatment has been in use a number of years, there is a need for study to balance design with chemical treatment available. This can be worked satisfactorily in large installations by use of pilot plants.

Varieties of raw water supplies are shown by giving examples of seven different cities over the country.

Of primary importance are flexible mixing facilities, proper flocculation, and careful handling of floc in settling basins in order to avoid breaking. Broken floc is slow to reform.

Of second importance is selection of the coagulant. The limitations of each coagulant should be recognized in light of knowledge of raw water to be treated.

A recent development is the greater use of iron salts for coagulation.

The use of chlorinated copperas and lime at Dallas is discussed. Two and one-half years of continuous use has resulted in satisfactory service and a total saving of $12,700.00 over the copperas lime treatment.

(*Presented before the Southwest Section meeting, October 12, 1936.*)

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THE OCCURRENCE OF GROUND WATER WITH REFERENCE TO CONTAMINATION[1]

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Water that is obtained from wells is derived from that part of the earth's crust in which the interstices or openings in the rocks are filled with water under hydrostatic pressure. This water is known as ground water or underground water. Its value as a source of water supply for human use is in a large measure dependent upon its bacterial purity.

Ground-water supplies in general, when properly developed in suitable localities, are usually of satisfactory bacteriologic quality. Their purity is the result of the action of many factors that tend not only to prevent the accumulation of contamination underground but also to prevent the transmission of harmful bacteria from an original source of contamination.

Were it not for the fact that many processes are constantly at work to prevent the accumulation of contamination underground all contamination that may have reached the ground water since the beginning of time would still be present in it. The procurement of potable ground water for human use would therefore be absolutely impossible. Among the factors mentioned by Stiles and Crohurst[2] as having a bearing upon the accumulation of bacteria are the hydrogen-ion concentration of the soil, the effect of drying because of changes in the level of the ground water, competition between bacteria, protozoan competition or the devouring of bacteria by other organisms, temperature, the presence or absence of a food supply, the natural death rate of bacteria, the effect of capillarity, which may carry bacteria into

[1] Published with the permission of the Director, U. S. Geological Survey.

[2] Stiles, C. W., Crohurst, H. C., Thomson, G. E., and Stearns, N. D., Experimental bacterial and chemical pollution of wells via ground water, with a report on the geology and ground-water hydrology of the experimental area at Fort Caswell, N. C.: U. S. Pub. Health Service, Hyg. Lab., Bull. 147, pp. 88–90, 1927.

the capillary fringe where they may die by drying, and the natural action of bacteria to seek an oxygen supply and hence accelerate the accumulation of the bacteria near the water table, where they may subsequently be unwatered by the lowering of the water table and be killed by drying.

The chief factors of the occurrence of ground water that have a bearing upon its contamination are (a) the character of the water-bearing rocks, particularly with reference to the size, shape, and arrangement of their interstices, and (b) the mode of occurrence, whether under water-table or artesian conditions.

CLASSIFICATION OF ROCKS[3]

Rocks may be classified with respect to their origin into three great classes—igneous rocks, sedimentary rocks, and metamorphic rocks. The markedly different sources of origin of these classes produce rocks of radically different character and hence considerable difference in their water-bearing properties.

Igneous rocks are produced by the cooling and solidification of molten masses of material from great depths below the surface, where the earth is very hot. These rocks differ widely in texture and water-bearing properties. Most of the igneous rocks that are now at the surface were solidified far below the surface and were originally very compact and nearly impervious—as, for example, unweathered granite. Water in quantities sufficient for well supplies occurs in such rocks largely in the joints and in the weathered surficial parts of the rocks. They are generally not profuse water-bearers. The lavas poured out upon the surface may, however, be so broken and vesicular that they will yield water in great abundance—as, for example, many of the basalts of the Northwestern States and Hawaii. Upon weathering these extrusive rocks become more compact and less permeable.

Sedimentary rocks are derived from older rocks by weathering and erosion—as, for example, by the deposition of gravel, sand, silt, and clay, by the deposition of calcareous and siliceous remains of animals, as in most of the limestones, marls, and related rocks, or by the chemical deposition of substances precipitated from solution, as in much of the flint and chert, caliche and some other limestones, gypsum, and

[3] For detailed classification of rocks and their water-bearing properties see Meinzer, O. E., Occurrence of ground water in the United States, with a discussion of principles: U. S. Geol. Survey Water-Supply Paper 489, 1923.

salt. Rocks of sedimentary origin include formations that are among our best water bearers—as, for example, gravel, sand, sandstone, and creviced limestone.

Metamorphic rocks are produced by the marked alteration of other rocks, chiefly at great depths, through the agency of heat and pressure. The principal rocks of this class are quartzite, slate, marble, schist, and gneiss. The metamorphic rocks are generally compact and nearly impervious, and they yield only meager supplies of water, chiefly from their joints, crevices, and cleavage planes or from the surficial weathered parts of the rocks.

RELATIONSHIP OF INTERSTICES TO THE TRANSMISSION OF CONTAMINATION

The size, shape, and interrelations of the interstices in the rocks are of primary importance in determining the bacteriologic quality of the water that accumulates below the ground-water table and supplies the wells and springs, for they determine largely the rapidity with which water may pass through a formation and the ability of the formation to filter out pollution. Formations that exert great filtering action on water passing through them, such as most formations of sand or sandstone, furnish the greatest protection against the transmission of pollution. On the other hand, formations that contain fissures and joints, large interstices, as in coarse, clean gravel, or solution channels, as in the creviced limestones, provide little filtering action and, moreover, may allow the water to move rapidly. Such formations may carry contamination through long distances from the original sources.

One of the best formations to yield water in abundance is clean, coarse gravel. It possesses all the essential characteristics of an excellent water-bearing rock, for it absorbs water freely, stores water in great volume, and yields water freely to wells. In this material there is essentially no water in the individual pieces of rock, but because the openings between the pieces are large and connected with one another water may move freely through it. Little filtering action of the water is provided, however, and hence contamination can move through the gravel readily.

If the void space of gravel is filled with material of smaller size, such as sand, the water moves less freely than in the clean, coarse gravel, and, because the voids are smaller, the filtering action is correspondingly increased; hence, great protection against the trans-

mission of contamination is afforded. Obviously, a formation composed of sand alone provides maximum filtering action, and clean sands, therefore, are classed in the group of rocks that afford the greatest safety with respect to contamination. However, if the individual sand grains are very small the resistance to the movement of the water may be so great that the formation will not yield much water. A true clay has extremely small interstices, and even though its porosity may be greater than that of many deposits of sand or gravel, little or no water moves through it, and it is classed as non-water-bearing and impervious. As clay resists the movement of water, it also prevents the passage of bacteria, and hence it is effective in protecting underlying water-bearing beds from pollution and is an especially favorable material in which to seat a well casing that is intended to exclude surface contamination or undesirable ground water.

Between the clean sand deposits, through which water moves freely, and the non-water-bearing clays, there is a large miscellaneous group of materials composed of mixtures of coarse and fine material but predominantly clayey. Of such character are the poorly assorted materials of till or boulder clay that were laid down by glacial ice, many of the alluvial deposits formed under very changeable conditions, and most of the residual materials produced by the weathering of igneous and metamorphic rocks. Such materials will not generally yield much water, but in many sections where they lie near the surface they yield small supplies to dug wells. However, because the water supplied to the wells may be transmitted largely through small crevices, these materials do not provide the maximum protection against pollution.

When individual grains of a deposit of sand become cemented together and the deposit becomes more or less hardened the formation is called a sandstone. As long as the interstices are not completely filled, sandstone has the same general properties as incoherent sand with respect to the movement of both water and contamination. If the interstices are completely filled, the sandstone becomes essentially impervious, and any water that occurs in it in sufficient quantity to be useful as a source of water supply is found in fissures, crevices, and joints. In addition to hard sandstone, other rocks that contain water largely in fissures, crevices, and joints are the hard brittle shales, the dense igneous rocks, such as granite and trap rock, and most of the metamorphic rocks, such as quartzite, slate,

gneiss, and schist. Because the joints, fissures, and crevices provide little filtering action to water passing through them, contamination can be transmitted for considerable distances through these rocks, although not as readily as through creviced limestone, broken lava rock, or coarse, clean gravel. Unweathered extrusive lava rocks may yield water chiefly from large openings that permit very free circulation of water. These openings may be due to the broken condition of the rocks or to the expansion of steam or other gas when pressure was removed during the process of cooling. The largest openings may consist of caverns and tunnels formed during the process of congealing from a molten state.

Unweathered limestone may be porous and permeable but it is generally compact and nearly impermeable except along its joints. Weathered limestone, however, generally contains numerous crevices, cavities, and channels that have resulted from the solution of portions of the rock by water that penetrated preexisting openings. Some of these openings have attained enormous size, as in the large caverns that are so common in limestone regions. Limestones may yield very large quantities of water from such openings. Because the large openings in both lava and limestone afford almost no filtering action, contamination can be transmitted through them freely for great distances.

PRINCIPLES OF OCCURRENCE

Water-table conditions

The protection of ground-water supplies from contamination is, in large measure, dependent upon the mode of occurrence of the ground water. Under water-table conditions surface waters and liquid wastes are free to percolate downward through the openings in the soil and rocks and to reach the water table, or upper surface of the zone of saturation. Obviously, therefore, the greatest measure of protection to wells tapping ground-water supplies occurring under water-table conditions is afforded by locating the wells as far as possible from all surface sources of contamination. Considerable protection to the supply is furnished by soils and subsoils that are effective as filters or by the presence of impervious material between the surface and the water table. Impervious material, such as a stratum of tight clay, will interrupt the downward percolation of pollution and prevent it from reaching the main body of ground water that supplies the well. Hence wherever possible the casings of wells

should be tightly sealed in such formations, especially to exclude shallow ground waters that may be contaminated. In many places that have no impervious layer considerable protection from contamination can be provided by extending a tight casing as far as practicable below the water table.

Artesian conditions

Ground water occurring under artesian conditions is confined under hydrostatic pressure in permeable formations that are overlain by more or less impervious beds. The artesian water is not of local origin but percolates laterally from a more or less distant intake area and is generally free of contamination at any considerable distance from the intake area. Because of the outward pressure of the water, wells that tap artesian aquifers are also the best protected so far as surface contamination in the vicinity of the wells is concerned, especially if the pressure is great enough to cause the water to overflow at the surface. However, if the water does not overflow, the process of pumping may introduce contamination into the well through defective casing at any point above the water level in the well. Moreover, contamination may be introduced into the artesian reservoir through nonflowing artesian wells that are open to polluting agencies at the surface or through defective casing. All abandoned wells tapping the same source should therefore be tightly sealed by approved methods. The practice of using wells for drainage or as a means of disposing of sewage or other wastes is obviously dangerous.

Rate and direction of movement of ground water

Ground water is generally moving from an area of surface intake to an area of natural discharge except as it is diverted toward wells that are pumped or flow by artesian pressure. This movement is the result of difference of head in the ground-water system and is in the direction of the slope of the water table under water-table conditions or in the direction of the hydraulic gradient in an artesian system. The shape of the water table can be determined by measurements of the depth to water in a sufficient number of wells that are not affected by draw-down through pumping and by referring such measurements to sea level or other datum plane. In areas where artesian conditions exist the hydraulic gradient or the shape of the piezometric or pressure-indicating surface can be determined in a similar manner by measuring the shut-in pressure of flowing artesian wells and the depth

to the water level in nonflowing artesian wells and converting the pressure readings into head of water. In most parts of humid regions the water table is built up from time to time by water penetrating from the surface during periods of heavy rain or in the spring when the frost leaves the ground. Natural discharge of the ground water, however, occurs only in low places. In humid regions, therefore, the water table generally slopes in nearly the same direction as the land surface, except where conditions have been modified by drainage, pumping from wells, or other agencies.

The direction of the movement of the ground water is an important factor in connection with the transmission of contamination. It is well established that contamination moves in the same direction as the ground water, and hence, as a general rule, wells should be installed up the slope and not down the slope of the water table from possible sources of contamination.

The rate of movement of the ground water[4] has an important relation to the transmission of contamination from its source to the wells. However, definite data on the transmission of contamination by ground water are very meager. Obviously the bacteriologic control of experiments to determine the rate of transmission is extremely difficult. Furthermore, because of the wide range in the water-bearing capacity of different rocks, great caution must be exercised in applying specific experimental results to places where the conditions are not strictly comparable. Attempts have been made to apply filtration rates as used in the operation of slow sand filters as guides in determining rates of movement of ground water that may be considered as being within general limits of safety. The merit of such standards is open to question, for the conditions are so greatly dissimilar that it is doubtful if there is any valid basis of comparison. It is fairly well established, however, that the great body of ground water is generally free from dangerous pollution except near the water table in the proximity of polluting agencies and except in very open rocks, such as cavernous limestone, extrusive lava rock, or coarse, clean gravel, in which contamination may be carried long distances. Experiments by Stiles[5] and his assistants at Fort Caswell, N. C., fully

[4] For discussion of methods of determining rate of movement of ground water see Meinzer, O. E., Methods for estimating ground-water supplies: U. S. Geol. Survey Water-Supply Paper 638, pp. 126–131, 1932; Movements of ground water: Am. Assoc. Petroleum Geologists Bull., vol. 20, no. 6, June 1936.

[5] Stiles, C. W., and others, op. cit., p. 11.

support this conclusion. Recognition of these general facts will aid greatly in adopting a safe practice in ground-water developments. Fortunately, small water supplies, such as are furnished by individual farm or domestic wells, are drawn from relatively small areas and can generally be made safe by locating the well up the slope and as far as practicable from possible sources of pollution and by proper well construction. Wells that are heavily pumped, as for public waterworks, draw their supplies from greater distances, and therefore, in the nature of the case, greater precautions are required to assure safety.

Effect of pumping

When water is pumped from a well a so-called cone of depression is created in the water table immediately surrounding the well. The base of the cone of depression is of varying diameter, depending upon the rate of pumping and the nature of the water-bearing formation. The circumference of the base defines what is known as the area of influence, and any sources of contamination within the area of influence are potential sources of danger to the supply.

The mere fact that a well is situated up the slope of the water table with reference to a source of contamination does not assure absolute protection against contamination, as the normal movement of the water in the vicinity of the well is modified when the well is pumped. The existence of a cone of depression in the vicinity of a pumped well indicates movement of water from all directions toward the well. Therefore, even though a source of contamination may be down the natural slope of the water table from a pumped well, if it is within the area of influence of the well it may contaminate the supply. Obviously the remedy to be applied under such conditions is to abandon the well and sink another at a greater distance from the source of danger or to remove the source of danger.

Under artesian conditions a well yielding water by natural flow or by pumping creates a cone of depression in the pressure-indicating surface surrounding the well, but it does not unwater a portion of the formation, as under water-table conditions, unless the draft is unusually heavy. As the pressure of the water in the artesian aquifer is outward, protection is afforded against contamination from the nearby surface. However, in nonflowing wells or in flowing wells in which the water level is lowered below the surface by pumping, contamination may enter the well at the surface or through defective

casing at any point above the water level in the well. Moreover, contamination may get into the artesian formation through any non-flowing artesian well, and thence into the water supply of any flowing or pumped artesian well whose area of influence is sufficiently extensive.

(*Presented before the Four-States Section meeting, April 24, 1936.*)

A DIRECT PLATING METHOD FOR THE DETERMINATION OF THE POTABILITY OF WATER[1]

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The "standard" method for the determination of E. Coli in potable or slightly polluted waters involves defects inherent in the isolation of any organism by means of enrichment in liquid media, as well as the lapse of 72 hours before the presence of the colon bacillus can be partially confirmed. Many attempts have been made to simplify the standard procedure; modifications based upon liquid media to which dyes or other inhibitory agents have been added are not within the scope of this paper, and only methods involving the use of solid media will be discussed.

Norton (8) says "While dye containing media have a legitimate and important use in the water purification field, there is no doubt that these media tend to reduce the number of isolations of the coli-aerogenes group. Direct plating methods, while theoretically superior to enrichment processes have not been developed to a point of practicability. The present 'standard' methods are far from perfect, and the coli aerogenes counts or indices obtained by them are undoubtedly too low rather than too high."

Skinner and Murray (10) found that the addition of crystal violet in the concentration of 1 part to 100,000 parts of eosin-methylene blue agar inhibited the development of spreading colonies while the characteristics of E. Coli were made more pronounced. Differentiation of E. Coli and A. aerogenes by means of colony appearance was found to be fairly reliable. This modified E.M.B. agar was used for streaking from lactose broth. Ruchhoft et al. (9) found Levine's E.M.B. agar or Skinner and Murray's modified agar to be best for purposes of isolation, but concluded neither medium was ideal. Due to the incidence of mixed colonies and the masking effect of the non-

[1] Journal Series paper N. J. Agricultural Experiment Station, New Brunswick, N. J. Division Water and Sewage Research.

members of the group, differentiation on the routine E.M.B. plate by macroscopic examination proved to be unsuccessful. Ruchhoft and associates failed to substantiate Skinner and Murray's claims for their modification of E.M.B. agar. Our experience, however, would indicate crystal violet to be of the highest value when used with E.M.B. agar. Since Ruchhoft et al. made use of dehydrated Difco E.M.B. agar, and Skinner and Murray, and this writer made up the agar from the raw materials, it would seem possible to ascribe the differences encountered to differences in the final composition.

Noble (5) in 1928, devised a ferrocyanide-citrate containing medium which he used in pour plates with considerable success, Tonney and Noble (11) improving the formula in 1931. These workers made the following claims: (1) Colon index is obtained in 42 to 48 hours, and represents more accurately the actual numbers present than does that obtained by lactose broth. (2) The direct counts on ferrocyanide citrate agar are not obscured by overgrowths and are not infered with, by common lactose fermenting organisms. (3) Further confirmation following growth on ferrocyanide-citrate agar appears to be unnecessary. (4) In pure culture work the poured plate is much superior to either Endo's medium or E.M.B. agar. (5) Differentiation between fecal coli and the aerogenes group is reasonably accurate. It should be pointed out, however, that other workers have not always been successful in making use of Noble's medium. Much care is required in making up the agar, and considerable experience is necessary in order to readily differentiate between the fecal and non-fecal groups. Further, Nolte and Kramer (7) found ferrocyanide-citrate agar to be unsuitable for waters of high purity, since the colon organisms did not give rise to characteristic colonies.

Levine (4) retained the standard procedure in all respects save time of incubation of the standard portions in lactose broth and was able to confirm partially the presence of the colon bacillus in 24 hours. Incubation of the sample in lactose broth was for 10 hours, followed by smearing (all portions) on E.M.B. agar, the entire test being completed in 24 hours. Growth on the plates was very rapid due to the transfer of the organisms while in the growth period of logarithmic increase. The major objection to this procedure is the danger that where E. Coli is present in very small numbers initially, or where they have become attenuated, as by chlorination, the transfer will not contain the organisms.

Gehm and Heukelekian (2) utilized E.M.B. agar for the rapid direct enumeration of E. Coli in polluted waters and sewage. They spread 1 ml. of the proper dilution of the sample on the surface of the E.M.B. plate and dried in the incubator with the cover removed; the plates were then closed and incubated for 24 hours. They claimed the following advantages: (1) Confirmed results in 24 hours, (2) less work involved, (3) less equipment required, (4) media cheaper and easier to prepare, (5) comparable counts are obtained with brilliant green bile.

Noble and Tonney (6) devised a new solid brilliant green bile medium, of complicated formula, which they used in pour plates, and which permitted counts in 17 to 19 hours. The productivity of this agar was greater than that of brilliant green lactose bile broth, but was less than that of standard lactose broth, and considerably less than that of ferrocyanide citrate agar. Expressed in percentage of standard lactose broth these values were 63.7, 66.0, and 115.1 respectively.

Attempts have been made to increase the concentration of E. Coli in given volumes of water in order that analyses may be simplified. While numerous methods for bacterial concentration have long been known, only such methods as affect the viable cells but slightly, can be used for the enumeration of living organisms.

Barsov and Sochilova (1) presented an ingenious technic for concentrating the organisms present in fairly large volumes of water. The water was filtered through a nitrocellulose membrane, which was then placed, bacterial layer uppermost, on the surface of modified Endo agar, and incubated for 24 hours. The passage of nutrients through the pores was found sufficient for normal colony growth, and typical colonies were produced. Endo's medium was modified by replacement of lactose by glucose, and the addition of 0.1 percent of phenol. Hoek (3) employed the same general method of concentration of sample, but differed in detail. A layer of diatomaceous earth was deposited from a suspension on a bacterial filter of the plate type, after which the required amount of water was drawn through. The numbers of E. Coli present in the diatomaceous earth layer were then determined by appropriate means. In pure culture work it was shown that 67 percent of the colon bacilli present in a light suspension were retained.

All of the methods, so far discussed for the enumeration of E. Coli when present in numbers within or near those permitted in a potable

water, have both advantages and defects. None would seem adequate for large numbers of routine bacteriological analyses with results obtainable within a reasonably short period of time. The following simple procedure has been used successfully in this laboratory. Samples are concentrated by centrifuging with infusorial earth or kaolin, decanting, and smearing on Skinner and Murray triple dye agar after the method of Gehm and Heukelekian. Any size sample may be analyzed, and results are obtainable within 18 to 36 hours. Results correlate well with those arrived at by the standard method.

METHODS

The medium[2] used is the Skinner and Murray (10) modification of Levine's simplified E.M.B. agar, the crystal violet concentration being changed to 1 part in 120,000 parts of medium, since experience has shown that higher concentrations may decrease the growth rate of the E. Coli strains present in natural waters. Plates usually are poured at some convenient time and stored at low temperature. Before use the required number are brought to at least room temperature. Fifty milliliter centrifuge tubes with the mouth covered by lead foil caps are sterilized in the autoclave. These tubes are file marked at 5 ml. and 50 ml. and are filled with aseptic precautions to the 50 ml. mark with the samples to be tested. If it is desired to determine the presence or absence of E. Coli in amounts of water greater than 50 ml. two or more tubes may be used per sample. To each 50 ml. portion of water is added 1 ml. of sterile aqueous 20 per-

[2] The triple dye agar used in this work has the following composition:

	Per liter
Peptone	10.0 grams
Dipotassium phosphate (K_2HPO_4)	2 grams
Agar	20 grams

Boil until the agar is dissolved, measure 600 ml. amounts in liter flasks, and sterilize for 15 minutes at 15 pounds. When plates are to be poured add to each 600 ml. melted portion the following:

Sterile 20% lactose	30 ml.
Aqueous 4% sol. eosin yellow	6 ml.
Aqueous 1% methylene blue	6 ml.
Aqueous 0.1% crystal violet	5 ml.

The plates are poured fairly thick, and may be stored in the refrigerator for long periods without spoilage.

cent suspension of kaolin. After centrifuging for 20 minutes at 2500 r.p.m. the supernatant is decanted until 5 ml. remain in the tube. After thorough mixing of the sediment one ml. portions are smeared on the surface of five triple-dye agar plates. These plates are then placed uncovered in the 37° incubator until their surfaces are dry, this usually requiring from 30 to 90 minutes, depending on the humidity of the air. Incubation is at 37°C. for an 18 to 36 hour period, this being dependent upon the rapidity of growth of the particular strains of E. Coli encountered in the water under test. The plates obtained by means of this procedure invariably have been found to contain well spaced colonies unobscured by the presence of "spreaders." In most instances colonies appear to be present in pure culture. The characteristics of the Coli-aerogenes group are at least as pronounced as on the same agar used in the "partially confirmed" step of the standard method.

EXPERIMENTAL

Pure cultures of E. Coli were suspended in sterile phosphate buffered dilution water in diminishing concentrations. Sterile infusorial earth (1 cc. of 10 percent) were added and the suspensions were centrifuged at 2500 r.p.m. for 20 minutes. The numbers of E. Coli present in the whole suspension were determined or calculated, and those in the sludge and in the supernatant were determined.

As an example the results obtained from one series are presented in table 1. Three suspensions were made, suspension II containing theoretically one-hundredth and suspension III one-thousandth as many organisms as did suspension I. Numbers of E. Coli were determined in whole suspension I by the smear method on triple dye agar, and calculated in suspensions II and III. The smear method was used for determination of numbers in the sludge, and in the supernatant; portions of initial suspension I, and supernatants II and III were added to lactose broth in 10 ml. portions, and numbers of E. Coli were estimated. In the densest suspension (I) 7500 E. Coli were found in the 50 ml. sample taken. In the sludge, after centrifuging, 4800 E. Coli were recovered, or 64 per cent of those present in the original suspension, while 1900 E. Coli remained in the entire supernatant, representing 25 percent of those originally present, so that a total of 89 percent of the viable cells originally estimated to be present were recovered. In suspensions II and III 104 and 80 percent of the organisms calculated to be originally present were found

in the sludge, and 5 and 27 percent in the supernatant. It must be kept in mind that in this experiment the numbers in the more dilute original suspensions were not actually obtained but were estimates based on the numbers found in suspension I, and the extent to which this suspension was diluted. The precipitation of 64 percent of the bacteria as found in the first instance should therefore most nearly represent actual removal.

TABLE 1

The distribution of E. Coli in the sediment and the supernatant after centrifuging suspensions of pure culture with infusorial earth†*

	SUSPENSION I	SUSPENSION II	SUSPENSION III
	Original	Original suspension diluted 1:100	Original suspension diluted 1:1000
E. Coli/ml. in suspension	150‡	1.5§	0.15§
E. Coli in 50 ml. sample	7500	75	7.5
E. Coli in sediment	4800	78	6
E. Coli/ml. in supernatant	38	0.08	0.04
E. Coli in 50 ml. supernatant	1900	4	2
E. Coli recovered in sediment + supernatant	6700	82	8
Percent total E. Coli recovered in sediment	64.0	104.0	80.0
Percent total E. Coli recovered in supernatant	25.3	5.3	26.7
Percent total E. Coli recovered in sediment + supernatant	89.3	109.3	106.7

* 2500 r.p.m. for 20 minutes.

† 1 ml. 20 percent infusorial earth per 50 ml. sample.

‡ Determined.

§ Calculated.

In order to show the value of centrifuging a bacterial suspension in the presence of infusorial earth as compared with centrifuging in its absence, results obtained are given in table 2. Two to three times as many organisms were centrifuged out of suspension when the inert material was present as when it was absent. This may be due to two factors: (1) the adsorption of cells, with a consequent removal from the liquid, on the surface of the larger particles and (2) the formation of a kaolin or infusorial earth layer which is not readily disturbed during decantation, in and on which the organisms are held.

In the following experiment the removal of E. Coli with kaolin

TABLE 2

The distribution of E. Coli in the sediment and the supernatant after centrifuging suspensions of pure culture with and without infusorial earth†*

	CENTRIFUGED WITHOUT INFUSORIAL EARTH		CENTRIFUGED WITH INFUSORIAL EARTH	
	Suspension I	Suspension II	Suspension I	Suspension II
	Original	Original suspension diluted 1:10	Original	Original suspension diluted 1:10
E. Coli/ml. in suspension	19‡	1.9§	19‡	1.9§
E. Coli in 50 ml. sample	950	95	950	95
E. Coli in sediment	211	20	448	61
E. Coli/ml. in supernatant	11	1	4	1
E. Coli in 50 cc. supernatant	550	50	200	50
E. Coli recovered in sediment and supernatant	761	70	648	111
Percent total E. Coli recovered in sediment	22.2	21.1	47.2	64.2
Percent total E. Coli recovered in supernatant	57.9	52.6	21.0	52.6
Percent total E. Coli recovered in sediment + supernatant	80.1	73.7	68.2	116.8

* 2500 r.p.m. for 20 minutes.
† 2 ml. 10 percent infusorial earth per 50 ml. sample.
‡ Determined.
§ Calculated.

TABLE 3

The distribution of E. Coli in the sediment and the supernatant after centrifuging suspension of a pure culture with kaolin†*

	TOTAL VOLUME	VOLUME OF SAMPLE	PLAIN AGAR		TRIPLE DYE AGAR		E. COLI IN TOTAL VOLUME; AVERAGE OF PLAIN AGAR AND TRIPLE DYE AGAR COUNTS	RECOVERY OF THE INITIAL E. COLI
			E. Coli in sample	E. Coli in total volume	E. Coli in sample	E. Coli in total volume		
	ml.	*ml.*						*percent*
Initial suspension	340	50	17	116	19	129	123	100.0
Sediment	60	10	14	84	15	90	87	71.0
Supernatant	320	50	6	38	5	32	35	28.5
Sediment + supernatant				122		122	122	99.5

* 2500 r.p.m. for 20 minutes.
† 1 ml. 20 percent kaolin per 50 ml. sample.

was determined with more refined technic. A suspension of known E. Coli content was diluted until it contained theoretically one E. Coli in 3 ml. A 50 ml. portion was plated in 5 ml. amounts in plain agar, and another 50 ml. portion in 1 ml. amounts on triple dye agar, 10 and 50 plates, respectively, being used. Of this suspension 340 ml. were centrifuged for 20 minutes at 2500 r.p.m. after the addition of

TABLE 4

Comparison of the numbers of E. Coli in a group of natural waters as determined by the Standard Method and by direct plating of the sediment after centrifuging with kaolin†*

SAMPLE NUMBER	NUMBER OF SAMPLES	DIRECT PLATING—NUMBER PLATES POSITIVE CORRESPONDING TO FIVE 10 ML. PORTIONS	STANDARD METHOD	
			Presumptive test—number positive of FIVE 10 ml. portions	Partially confirmed test—number positive of 5-10 ml. portions
1-18	18	0	0	0
19	1	0	1+	0
20	1	0	2+	0
21	1	0	3+; 2±	1+
22	1	0	4+	0
23	1	1+	0	0
24	1	2+	5±	0
25	1	2+	5+	1+
26	1	3+	2±	0
27	1	3+	2+	2+
28	1	3+	3+	3+
29	1	4+	1+	1+
30	1	4+	4+	5+
31	1	5+	5±	1+
32	1	5+	1+; 4±	3+
33	1	5+	2+; 3±	4+
34	1	5+	4+	4+
35-38	4	5+	5+	4+
39-46	8	5+	5+	5+

* 2500 r.p.m. for 20 minutes.

† 1 ml. 20 percent kaolin per 50 ml. sample.

1 ml. 20 percent sterile kaolin suspension per 50 ml. sample. The supernatant was decanted, and the sludge obtained was made up to 60 ml. Two 10 ml. aliquots were distributed in 1 ml. portions in 10 plain agar pour plates, and on triple dye agar plates. The supernatant liquor (320 ml.) was treated exactly as had been the original suspension. Results are presented in table 3. Since dif-

ferences between the counts as obtained by means of plain agar pour plates and triple dye agar surface plates were found to be within the limits of experimental error, averages were taken of the two counts. With a total of 123 colon organisms present in 430 ml. of the original suspension 87, or 71 percent were recovered in the sludge after centrifuging, while 35, or 28.5 percent were recovered from the supernatant liquor, representing a total recovery of 99.5 percent of the viable cells.

APPLICATION OF THE CENTRIFUGE METHOD TO NATURAL WATERS

In the course of routine analyses of natural waters 46 different samples were examined bacteriologically by the standard method and by the centrifuge method using kaolin. The results of this series are condensed in table 4. The Standard method was modified to the extent that all of the five 10 ml. portions were streaked on triple-dye agar. Where the partially confirmed test was inconclusive further differential tests were employed. The waters in question were for the greater part well waters from various parts of New Jersey, with a few very slightly polluted lake waters.

DISCUSSION

The necessity of the presence of a finely divided inert substance for the more efficient removal of E. Coli by means of centrifuging has been demonstrated. Infusorial earth and kaolin may be interchanged without materially affecting the percentage removal of the organism from the liquid. This removal comprises from 60 to 70 percent of the viable cells of E. Coli in the original suspension. There is, therefore, an immediate loss in numbers of E. Coli, before enumeration has begun, of 30 to 40 percent. To what extent can this loss be expected to affect the status of a water as far as potability is concerned?

The superiority of a solid medium over liquid for purposes of isolation is so well known as to require little further discussion. Equally well known are the factors which tend to make unreliable the presumptive test, namely overgrowth by other forms, acid production and the like. When a viable cell of E. Coli is isolated on the surface of a solid medium favorable for its development it may be expected to form a colony, even though there be 200 cells of other organisms growing upon the same agar surface. Were the same single cell of E. Coli to be placed in lactose broth together with the 200 contaminants, reproduction in sufficient amount to be demonstrable by the

usual means would appear to be rather improbable. When it is further realized that the Skinner and Murray triple dye agar markedly reduces the numbers of the normal water flora while the effect upon E. Coli is very slight, the advantages of the solid medium becomes still more apparent. It is reasonable to believe that the loss of 30 to 40 percent of the original numbers of E. Coli by this method is more than balanced by the losses which unquestionably are experienced under the standard method.

The nature of the Treasury Department Standards of potability would likewise tend towards eliminating the initial loss as a source of discrepancy in judging a water. Those cases in which such loss could alter the status of the water must be comparatively few, and in any event would constitute border-line cases, deserving special

TABLE 5

Potability and correlation of the presumptive and confirmed tests of two groups of waters as determined by the standard method

GROUP	NUMBER ANALYSES	NUMBER* WATERS FOUND POTABLE	WATERS FOUND POTABLE	NUMBER ANALYSES	NUMBER WATERS WITH IDENTICAL PRESUMPTIVE AND PARTIALLY CONFIRMED TESTS	WATERS WITH IDENTICAL PRESUMPTIVE AND PARTIALLY CONFIRMED TESTS
			percent			*percent*
I†	46	30	65.2	46	31	67.4
II‡	438	257	58.7	218	128	58.7

* Based on U. S. Treasury Department Standard.

† Incorporates analyses performed in present study.

‡ Incorporates routine analyses covering 5-year period.

consideration. These theoretical considerations are confirmed in practice.

In table 4 it is shown that identical results through partial confirmation were obtained in 30 cases, representing 65.2 percent of the samples analyzed, by both of the methods used. In two cases, or 4.3 percent, higher values of E. Coli were found by the standard method than by the centrifuge method; in 14 cases, or 30.4 percent of all the samples run, the centrifuge method gave higher results. Further examination of the data reveals several interesting points. Although perfect correlation was achieved only in 65 percent of the cases, the classification (as arrived at by the Treasury Department Standard) of only 4 samples was affected by differences in results obtained by the two methods. In this limited series, therefore, as far as potability

of the waters is concerned, the results of the two methods correlated in 91.3 percent of the samples. It should be noted that three of the four differing waters would be condemned by the results obtained by centrifuging and accepted by the results of the standard method, while in only one instance was the reverse found to be the case.

In view of the comparatively small number of samples comprising this series it is of interest to compare it with a larger group of standard bacteriological analyses performed in this laboratory over a five year period (table 5). Thirty of the 46 analyses in the smaller group were acceptable as potable waters on the basis of E. Coli content as arrived at by the standard method, representing a percentage of 65.2. Of the 438 waters making up the larger group, 257, or 58.7 percent, contained E. Coli in numbers fewer than the Treasury Department limit. The percentage difference of the two groups is 6.5, and in this respect, at least, the groups need not be considered widely divergent.

Considering the two groups from the standpoint of correlation of the presumptive test with the partially confirmed test, it is seen that in the small group 31 or 67.4 percent of the 46 waters gave identical results for both of the above mentioned tests. The larger group in this instance is composed of 218 members, the number being smaller by reason of insufficient data. Perfect agreement between the presumptive and partially confirmed tests was reached in 128 cases, representing 58.7 percent. The two groups therefore vary by 8.7 percent when the basis of uniformity is agreement between these two standard tests. It is doubtful whether such variation is significant.

It would appear that the group of 46 waters incorporated in this study and collected widely over the State may be considered as fairly typical of the ground waters of New Jersey, as far as extent and type of pollution are concerned. It is fully realized, however, that more extended work must necessarily be undertaken before a new method can be generally accepted, and it is to be hoped that such work may be accomplished in water laboratories receiving large numbers of samples for analysis.

SUMMARY

A new method for the determination of small numbers of E. Coli in waters consisting essentially in centrifuging the water in the presence of an inert material, such as kaolin or infusorial earth followed by decantation and smearing of the residue on E.M.B.-crystal violet agar after the method of Gehm and Heukelekian is presented. Pure culture experiments indicate that 70 percent of the viable cells

of E. Coli present in dilute suspension may be removed from the liquor to the sediment under the conditions outlined above, with 30 percent remaining in the liquor. The centrifuge method for the demonstration of E. Coli permits partial confirmation in from 18 to 36 hours. Differentiation between E. Coli and A. Aerogenes is as well defined as is ever possible on the confirmatory agar employed. The centrifuge method produced higher E. Coli counts in 30 percent of the cases than the standard method; the reverse was true in only 4 percent of the cases. Identical results through partial confirmation were obtained by both the centrifuge and standard methods in 65 percent of the cases; the potability of the waters, however, as judged by the Treasury Department standard, was identical in 91 percent of the cases. The limited series of determinations made (46) did not differ materially in certain salient features from larger numbers analyzed in this laboratory over a five year period.

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THE QUALITY AND FITNESS OF OUR DEEP WELL WATER FOR THE MANUFACTURE OF PULP AND WHITE PAPER FROM SLASH PINE

By Charles H. Herty

(Director, Pulp and Paper Laboratory, Industrial Committee of Savannah, Inc., Savannah, Ga.)

Mayor Gamble has just spoken to you on water-supply from the standpoint of the health of citizens. May I discuss with you water from the standpoint of a chemist as it is required by industrial concerns as the most necessary feature of manufacturing operations, especially in the manufacture of pulp and paper, which promises to be the next great industrial development in this southeastern territory which is governed by your membership.

A recent survey by the Federal Government has shown an enormous wealth of pine and semi-hardwood timber in this practically untouched region. The figures of this survey are now attracting nation-wide attention, especially since the spruce woods of the Great Lakes and Eastern States are practically exhausted and this makes necessary the importation annually of some two hundred million dollars worth of pulp and paper.

About fifteen years ago when it was first proposed to manufacture kraft from southern pine it was loudly proclaimed that this was impossible, but during the intervening years there has been so rapid a growth of the kraft pulp and paper industries that the South now dominates the field with the manufacture of more than sixty percent of the national output. Now when it is proposed to use southern pine for white paper the same cry is heard about the unsuitability of southern pine.

The work in the Pulp and Paper Laboratory of the Industrial Committee of Savannah has completely disproved this contention. Erroneous ideas have been held regarding our pines: first, through the use of the name "yellow" pine, which applies only to the heart, while the sapwood gives a pulp actually lighter in color than spruce; and, second, the utilization of longleaf and slash pines for naval stores

led to the belief that such trees must be filled with resin, a dreaded difficulty in the manufacture of paper. This latter error arose from a lack of knowledge of the fact that the oleoresin gathered in turpentining is a pathological product manufactured by the tree right at the point of wounding. Analyses of sawdust from the untapped tree show very low resin content.

For four and a half years continuous research has been carried on in our laboratory, which is really a semi-commercial mill and a testing laboratory. As a result of this work all forms of white paper of full commercial quality have been produced. Here are samples of sulphite pulp, groundwood, and bleached sulphate pulp. Here are the products manufactured from them—newsprint, book, magazine, rotogravure and bond papers, and also samples of rayon.

From the upper portion of trees which have been turpentined and abandoned has been made beautiful newsprint, on which there was printed a supplement to the Weekly Naval Stores Review, showing thus the close coördination between the turpentine and the paper industries.

Of particular importance is the extremely rapid growth of pines in our South Atlantic and Gulf States compared with spruce in the Northern States. The ratio is seven or eight times as fast in the South in the case of pine as against that of spruce in the North.

To meet the criticism that our paper was made on a machine producing only one hundred feet per minute, whereas the commercial practice is carried out on a much faster machine, a shipment of three carloads of pulp manufactured in our plant was sent to a mill in Canada and there run over a fast commercial machine with perfect success. On the newsprint made thereby nine Georgia dailies got out their regular issues on November 20, 1933.

Careful estimates based on a great number of experiments show that while it costs, according to official records, something over $47.00 to manufacture and deliver to New York City, without interest or profit, a ton of newsprint from the average newsprint mill in the United States, a ton of equally good newsprint can be laid down in New York City from a South Atlantic port, without interest or profit, for a little over $27.00. Similar decreases are noted in the cost of other forms of white paper because of the corresponding low cost of production of the pulps from which they are made.

But even with this complete demonstration, and with the knowledge of the great timber resources from the special survey, there is

still one important factor which determines the ability to manufacture, viz. water. On this point we are sadly lacking in full information as to the chemical composition of our waters and the volume of flow of our streams.

Throughout the Coastal Plain two types of water are available. First, the artesian water, such as we use daily in our laboratory. It is characterized by high temporary hardness. It is very clear and answers excellently for all forms of pulp and paper except such pulps as are used for the manufacture of rayon. In this, however, by the use of zeolite softeners it can be changed to a suitable softness and excellent rayon produced. It is very desirable to know to what extent any great amount of large-scale tapping of this source of artesian water may reduce the available supply.

Second, the river waters which come down from the Piedmont area are filled with suspended mud. However, these same muddy waters can, by the use of settling basins and treatment with alum, be changed into the finest type of industrial waters. The Savannah Sugar Refinery makes use of the water of the Savannah River after such purification in its refining of sugar. It is important to know what the cost of such purification would be to an industrial plant. Unfortunately, most of the data available today are from city waterworks where bookkeeping includes the cost of maintenance of water-mains and pumping to suitable reservoirs.

On many of our streams there is no record of complete chemical analysis. I have no doubt that in the records of your various members there are bits of information which could be put together into a helpful picture. But, after all, the great need, especially in Georgia, is for coöperation—State coöperation with the United States Geological Survey on a 50-50 basis of expense, whereby analyses can be made of all waters, and, through the establishment of many gauging stations, accurate data can be compiled from year to year of the volume of flow of important streams, rivers and creeks.

All other states adjoining Georgia are coöperating in this way at present. Therefore, the Georgia Forestry Association has appointed a committee which will seek to raise $10,000 to initiate this coöperative work as quickly as possible in the confident belief that having inaugurated it the State will by legislative appropriation continue for a long series of years the compilation of these data so necessary for the industrial development of the state.

An average commercial papermill would require about three

million gallons of water daily. It is required to dissolve chemicals, to dilute pulps so that they may be pumped to different portions of the mill, for flowing the pulps over the paper machine wires, and for keeping these wires clean of every adherent particle. The pulps themselves must be washed with great care to free them of every trace of chemicals.

No matter how rich the timber resources of a section may be the presence of a plentiful supply of suitable water is absolutely essential for papermaking. You will thus see how closely that subject with which your association in this southeastern territory is bound bears so directly on the future development of a great new industry which will bring abundant prosperity to our people.

I bespeak your interest and aid in securing funds for such a survey, in educating our people as to the needs of such knowledge, and that you from your own data fill in as far as possible the gap which must intervene before this systematic investigation can begin.

As men devoted to the public interest I feel that we can count with confidence upon your coöperation.

(*Presented before the Southeastern Section meeting, April 7, 1936.*)

RED WATER TROUBLES AND LOW TEMPERATURES OF WINTER OF 1936

By R. B. Simms

(Superintendent, Water Works and Sewage Disposal, Spartanburg, S.C.)

The greatest obstacle the water works man has in this day of refinement is red water, not red water from the source but water that has changed color after leaving the plant, say one to ten days, sometimes red, sometimes yellow, and sometimes black. The causes of this condition vary almost with each dead end in your city and especially does it vary with each city.

In Spartanburg we have an ideal red water breeding condition. We boast of available water for every home, however humble, inside the city limits. We also boast of fire protection for every group of houses. This, as you realize, necessitates a number of dead ends and each dead end is a breeder of trouble.

This trouble was aggravated by our 1936 extremely cold weather over a long period, the temperatures of the water in Spartanburg going as low as 35 degrees in January, with February having a mean temperature of 40 degrees, March 50 degrees. April 57 degrees, May 67 degrees and with a high in July of 80 degrees. This, in our opinion, developed one of the worst conditions we have experienced since operating under the new regime of laboratory control. To be frank with you, our pride was taken down several notches by the fact that we had let this water get from under our control.

After going over all of our records thoroughly with Dr. C. B. Waller, Chemist at Wofford College and Spartanburg Water Works, our Engineer-Chemist, Mr. J. K. Marquis, and the filter plant operators, we could not determine from the records anything that had been neglected or overlooked.

To correct our red water conditions quickly, we made a change in the sterilization, cut the ammonia off for a few days and reduced the chlorine, watching very carefully all of our filtered water, and flushed all of our dead ends several times, etc. One of the things that we suspected was that during this extremely low temperature condition

ice came on the filters continuously and did not give proper coagulation. We suspected that some free alum had gotten through the filter beds. However, we could not confirm this. We continued our search by sending out a questionnaire to comparable cities in the Piedmont section, Columbia, Newberry, Lyman, Greenwood, Atlanta, and Charlotte, (Charlotte being the only city that did not answer our questionnaire). In this questionnaire we asked for and found that they vary in practically every city.

Columbia, Guy H. White: Mr. White says tnat from the record sent him it looks as if there is something in the water that has not been taken into consideration. The sudden temperature changes might cause poor flocculation and that the alum reaction is not completed before filtration but finally finishes the reaction in the distribution

TABLE 1

MAY 19, 1926	pH OF RAW WATER	pH OF FINISHED WATER	CO_2 OF FINISHED WATER	pH OF MARBLE TEST	HARDNESS, SOAP TEST	CHLORINE AND AMMONIA RESIDUAL	CHLORINE ONLY RESIDUAL	ALUM, GRAINS PER GALLON	LIME, GRAINS PER GALLON	TURBIDITY, AVERAGE	SODA ASH, GRAINS PER GALLON
Spartanburg	6.8	8.4	0	8.3	30	0.24		0.56	0.38	76	
Columbia	6.8	6.8	2.2		21.5		22	1.47	0.66	143	
Newberry	7.1	8.2		7.9	36.4	0.2		1.47	0.86	108	
Lyman	6.6	8.1		8.1	3.2	0.4		0.70		65	0.80
Greenwood	6.9	7.8		7.7			0.3	1.38	0.9		
Atlanta	6.9	8.0		8.4	19.5	0.25		0.58	0.31	120	

system. He says these conditions are unusual for this plant, but were experienced during the past winter.

Newberry, Homer Schumpert: Mr. Schumpert suggests hydrated lime with highest calcium hydroxide possible, also that we run test for free alum in our filter effluent due to the continued cold weather, and that we watch the pH in different places in the city and change the lime treatment so as to coördinate the different pH conditions of the city. He thinks we would always get red water from reheated water, and claims that water once heated, if well heated, should be used or thrown away, for otherwise the pipes and tanks will surely be eaten therewith. (In Spartanburg, we find that water heated too quickly or too hot will invariably cause red water.)

Lyman, Marshall Bright: Mr. Bright raised the question if our

water in the last few years had not become more acid and if the acidity were not increasing slightly from year to year. He says that the pH of the coagulated water should be raised a little higher than the pH of the raw water at certain seasons of the year to prevent free alum, especially in very cold weather when free alum gets through, and suggests the constant use of flocculator.

Greenwood, F. W. Chapman: Mr. Chapman suggests that if a dose of alum is used during cold weather, there is a chance of quite a lot of free alum going into the filter which would create a certain amount of rust in the mains without a doubt and that we should undoubtedly increase the lime dose in the filtered water at certain seasons of the year. Mr. Chapman's experience is that the change in the pH or character of the water and in the main causes a loosening of the scale and red water. He further advises us to look out for dissolved oxygen on account of our new tank and also on account of the cold weather.

Atlanta, Paul Weir: Mr. Weir frankly admits that Atlanta's troubles and Spartanburg's troubles are identical with red or yellow water, depending on the stage at which you catch it. In Mr. Weir's opinion, the foremost cause of our trouble is temperature differential, as his water went to 34 degrees (Spartanburg's to 36 degrees). This, of course, caused a greater viscosity and likewise a greater amount of oxygen absorbed and where the dead end is is the place where the latter finally comes to rest in a low velocity and corrosion begins. Mr. Weir states that there is a possibility that an excess application of chlorine and ammonia throughout the year, forming chloramines, may contribute to excessive discolored water trouble as it is claimed that chloramine is decidedly toxic to iron bacteria which we often call tuberculation in the advanced stage of pipe corrosion. Mr. Weir's observation is that marble tests change from season to season and that the test should be run practically each month to establish this seasonal change (24 hr. set up). He says that a pH of one- to two-tenths higher than the marble test should be maintained, provided it does not create taste and odor. He thinks that a change from lime to soda ash should be considered seriously before adoption due to a change in the film coatings, etc., and that activated carbon is a doseable adjunct to almost every water treatment plant. Mr. Weir suggests that less than 0.20 ppm. residual chloramine in the filter effluent be carried. His experience checks further with Spartanburg's experience in that these conditions are seasonable and become

more aggravated in the rising temperature and until the maximum is reached, and then decrease through falling temperatures. He says that the only remedy is either bleeding the dead ends or flushing the hydrants.

Spartanburg's Reaction: The above synopsis of reports have been posted for filter plant operators' study with a few changes. Our first turbidity meter was purchased, a flocculator installed, and chloramine residual reduced from 0.24 plus to 0.20 minus. It is found that our marble test changes from 7.8 to 8.3. In addition to the above, dead ends have been flushed and since the temperatures have become practically the same (after a rise from 36 to 60 degrees in forty-five days) there is a very marked improvement in the water in dead ends.

(*Presented before the South Carolina Section meeting, August 27, 1936.*)

TREATMENT OF FOX RIVER WATER BY THE SILVER MINERAL PROCESS

By W. U. Gallaher

(Water Department, Appleton, Wisconsin)

The germicidal or oligodynamic action of small quantities of silver and other metals has been known for sometime. Practical application of this method, however, has been made only since 1929 when Krause of Germany pushed the idea so energetically that it has been adopted quite extensively in his country in recent years.

There are two general methods disclosed in the European art for the treatment of water with silver. One method consists in introducing small quantities of silver into water by means of an electric current. The second method consists in bringing the water in contact with silver metal or silver coated material when sufficient silver goes into solution to destroy bacteria. The quantity of silver required to sterilize drinking water is usually quoted as from 0.025 to 0.100 milligram per liter with a contact period of 30 to 60 minutes.

The oligodynamic activity of silver has also been given some attention in this country during recent years. The subject of this investigation is an American process known as the Super-Ionite system that employs silver as the active germicidal agent. "Super-Ionite" mineral is a synthetic granular material made up of silver in combination with a type of base exchange silicate. The manufacturers claim for the material the following characteristics:

1. The silver is dispersed throughout the particles rather than being coated on the surfaces.
2. The bactericidal activity is claimed to be due in a large measure to its adsorptive properties for bacteria and is not wholly dependent upon silver going into solution in the effluent. This property is said to greatly increase its capacity, permitting a relatively short contact time with the water as compared to other contact type oligodynamic material.
3. It is claimed that the bactericidal activity of the material can be maintained by a periodic re-activation. This re-activa-

tion consists of passing a solution of harmless non-corrosive salts, in proper proportion, through the Super-Ionite mineral bed. It is claimed that the procedure frees the material from accretions and exposes new active surfaces.

During the months of November and December of 1935 an apparatus specified by the manufacturer as a Model C H Super-Ionite Domestic Drinking Water System was operated on the raw Fox River water at Appleton, Wisconsin. The unit embodied a porous filter stone, readily cleanable by turning a hand crank, the whole being mounted on the top and in the same container with a purifying column containing the granular Super-Ionite Mineral described above. The purifying column was 38 inches deep by 6 inches in diameter. Following the purifying bed was a 30 gallon pneumatic pressure tank for taking care of demand withdrawals. Both the inlet and outlet lines to the tank were near the bottom. The flow rate specified by the manufacturer for this apparatus was 5 to 7 gallons per hour when used on ordinary well water. The capacity between cleaning and reactivating periods when operating on reasonably clear well water was specified at 500 ballons. Since the average daily capacity in normal home use has been found to be about 20 gallons of drinking water, reactivation would be required only about once a month in actual service.

The Fox River carries the overflow from Lake Winnebago to Green Bay. Between Lake Winnebago and Appleton are introduced domestic sewage from a population of 19,000 and trade wastes equivalent to a population of 40,000. In addition, organic matter in Lake Winnebago water entering the Fox River is equivalent to a population of about 300,000; therefore the amount of organic matter and the bacterial concentration present in the Fox River were always relatively high.

The object of making tests on such highly polluted water was to determine the limitations of the Super-Ionite System when operating under the most extreme conditions prevailing, with a view to more clearly evaluating the normal utility of this system in the private well supply field. Von der Leedon in Vom Wasser 7, 90 (1933) has tabulated the known factors adversely affecting the bactericidal action of silver surfaces. Of these the dominant ones are (1) low temperatures, (2) organic matter in suspension, (3) organic matter in solution. The effect of low temperature is to slow both the rate of solution of the silver and the germicidal activity of the effluent.

Thus, longer contact with the metallic surfaces was required, as well as a longer standing time of the effluent. The effect of organic matter is to coat the active surfaces, and to absorb silver from the effluent, thus decreasing its germicidal strength. The Fox River supply permitted the above factors to be studied in connection with a process, claiming regenerative features, which features should prove useful in maintaining it at a known level of activity, even under adverse conditions.

RUN NO. 1—PRELIMINARY

A preliminary run was made from November 1 to November 9 in which 15 gallons of water were drawn every two hours. After withdrawals the stone was cleaned by scraping and washing. During all tests the unit was operated from 7 A.M. to 11 P.M. daily. This average daily withdrawal of about 100 gallons would represent about a week of normal use, according to the manufacturer.

The temperature of the river water dropped from 50 to 42 degrees F. during the course of this run. The color during this period was 25 to 30 and the turbidity 10 to 20. The total count of bacteria of the raw water was 20 to 4800 and the B. Coli Index varied from 1,000 to 100,000 per 100 cc.

Three samples of the effluent were taken daily for examination. The first sample, taken at 8 A.M. from the pneumatic pressure tank, represented water which had been standing in this tank since 10 P.M. the night before. This sample was labeled Sample A. The second sample was taken during the normal daily operation at 4 P.M. during regular withdrawal of water and under such conditions that it had had little or no storage time. This was labeled Sample B, and was set up immediately. The third sample was taken at 10 P.M. This sample, in a glass bottle, was stored in the refrigerator until the following morning and was set up with sample A. It will be observed that the only difference between sample A and the 10 P.M. sample is that the first had been stored in the pneumatic tank overnight, whereas the latter was stored in a glass bottle in the refrigerator, a like period of time. All samples were examined by the standard bacteriological procedure for drinking water.

The data (table 1), show that the total count was slightly reduced while the B. Coli was entirely eliminated by the treatment. As the run progressed, however, it became more and more difficult to obtain 15 gallons of water from the unit every two hours on account

of rapid filming and clogging up of the stone prefilter. A check was made and it was found that the stone was not being adequately cleaned and was so completely filmed, that it was removing the

TABLE 1

Super-ionite test. Preliminary Run No. 1, Nov. 1–8, 1935

GALLONS SINCE ACTIVATION	TOTAL BACTERIA COUNT, 37°C.					B. COLI INDEX PER 100 cc.				
	River	Entering super-ionite bed	Effluent A—8 a.m.	Effluent B—4 p.m.	Effluent C—10 p.m.	River	Entering super-ionite bed	Effluent A—8 a.m.	Effluent B—4 p.m.	Effluent C—10 p.m.
105	4,800		3			5,000		0.0		
149				370					0.0	
186					625					0.0
201	3,300		760			10,000		0.0		
265				300					0.0	
310			7,500			1,000		0.0		
370				1,400					0.0	
430	150		750			1,000		0.0		
521*					63					0.0
536	220		51			10,000		0.0		
617			6			1,000		0.0		
669					610					0.0
682	2,300		240			100,000		0.0		
693				3					0.0	
718	20		3			1,000		0.0		
726		3		3,200			6.0		0.0	
Average	1,800		1,164	1,055	433	16,000	6.0	0.0	0.0	0.0

* From 500 gallons on, the system was operating under conditions of overrun.

B. Coli before they reached the purifying mineral bed,—in one test reducing the B. Coli index from 1000 to 6 as the water passed through.

RUN NO. 2—ULTIMATE CAPACITY WITHOUT ACTIVATION

During the foregoing preliminary run, which lasted 8 days, the system had treated 726 gallons of water or approximately 50 percent

more than the manufacturer specifies between regenerations for normal well water treatment. In order to determine the point of markedly diminished capacity of the unit without regeneration on the Fox

TABLE 2

Super-ionite test. Run No. 2, Nov. 12–19. Over-run conditions

GALLONS SINCE ACTIVATION	TOTAL BACTERIA COUNT, 37°C.					B. COLI INDEX PER 100 CC.				
	River	Entering super-ionite bed	Effluent A— 8 a.m.	Effluent B— 4 p.m.	Effluent C— 10 p.m.	River	Entering super-ionite bed	Effluent A— 8 a.m.	Effluent B— 4 p.m.	Effluent C— 10 p.m.
798*	750	50	250			1,000	100	4.0		
853					250					0.0
878	1,100		820			10,000		0.0		
956					300					4.0
971	600	375	150			1,000	1,000	0.0		
1,022				110					6.0	
1,060					500					2.0
1,074	410		480			1,000		0.0		
1,159					10					2.0
1,173	375	1,025	150			10,000	1,000	0.0		
1,215				250					10+	
1,265			550					0.0		
1,306				4					100	
1,350	1,250		45			10,000		4.0		
1,379				1					100	
1,379†				(225)					(0.0)	
Average	750	480	350	91	265	5,500	700	1.1	54+	2.0

Note: B. Coli Index per 100 cc. effluent water equals number positive 10 cc. tubes times two.

* Over-run began at 500 gallons in previous test, i.e., Run No. I.

† No draw off, 24 hrs.

River Water, the next run (table 2) was a continuation of the first one, that is, the mineral was not activated at the start of the run. However, during the test, the stone was scraped and washed more

thoroughly than in the first run in order that it would not screen out bacteria, thus imposing the full bacterial load on the Super-Ionite bed.

The temperature of the river water dropped from 42 to 38 degrees F. during the period of Run No. 2 (Nov. 12–19). The average turbidity of the raw water during this period varied between 410 to 1250 and the B. Coli index from 1,000 to 10,000. In this run, as in the first, three samples were taken of the treated water each day, one at 8 A.M., one at 4 P.M., and the last at 10 P.M. As before, the 10 o'clock sample was stored in the refrigerator overnight.

Beginning with 50 percent overrun, based upon the reactivation schedule specified for normal water, the unit was shown to lose efficiency as the run progressed. When it reached 100 percent overrun, the current (4 P.M.) sample showed a B. Coli index of 6. At 150 percent overrun, or when the unit had delivered about 1250 gallons, the 4 P.M. sample had a B. Coli index of 100. It is interesting to note that a sample drawn after the unit had stood idle for 24 hours showed no B. Coli present. Samples taken at 8 A.M. were of better quality than those taken at 4 P.M. and 10 P.M. This water had been standing in the pneumatic pressure tank overnight. While it is true that the 10 P.M. and the 8 A.M. samples had identical storage time, it was consistently observed during all the foregoing runs that the 10 P.M. samples stored in a glass bottle were not always negative, whereas the 8 A.M. samples which had stood the same time were uniformly all negative. Von der Leedon in Vom Wasser, 7, 90, (1933) has shown that silver ion can be taken up by glass in the extremely small concentration met in oligodynamic solutions. Explanation is made on the basis of adsorption. This phenomenon would readily explain a discrepancy in results of the two samples.

Poorest results on this breakdown test with no regeneration show an average of 95 percent elimination on the 4 P.M. samples which are those having no standing time.

RUN NO. 3—MINERAL RECOVERY WITH ACTIVATION

The next run (table 3) was made to determine whether or not the unit would recover its efficiency if it were now activated according to the manufacturers' specifications. Accordingly, after activating, the system was again placed in operation under the same conditions as the previous run. In sampling, the 10 P.M. sample was eliminated.

The temperature of the river water dropped from 38 degrees F. to 34 degrees F. during the period of Run No. 3 (Nov. 21–26). The average turbidity was 17 and the average color 25. The total count of bacteria of the raw water lay between 80 and 1150 and the B. Coli index between 1,000 and 10,000.

The 8 A.M. samples showed no B. Coli present during the period of the 6 day run. The 4 P.M. or current samples averaged 1.5 out

TABLE 3

Super-ionite test. Run No. 3, Nov. 21–26. After field reactivation

DATE	GALLONS SINCE ACTIVATION	TOTAL BACTERIA COUNT, 37°C.				B. COLI INDEX PER 100 CC.			
		River	Entering super-ionite bed	Effluent		River	Entering super-ionite bed	Effluent	
				A—8 a.m.	B—4 p.m.			A—8 a.m.	B—4 p.m.
Nov. 21	92	190		1		1,000		0.0	
	144		600		2		1,000		2.0
Nov. 22	198	1,150		0		10,000		0.0	
	244				0				6.0
Nov. 23	294	620		0		1,000		0.0	
	343				200				0.0
Nov. 24	393			4		1,000		0.0	
Nov. 25	497	80		18		10,000		0.0	
	538		120		6		1,000+		4.0
Nov. 26	605	130		3		1,000		0.0	
Average.....		434	360	4	52	4,000	1,000+	0.0	3.0

Note: B. Coli Index per 100 cc. effluent equals number positive 10 cc. tubes times two.

of 5 tubes positive with a maximum of 3 out of 5 tubes positive. Although the latter samples, with no storage, did not conform to the U. S. Public Health Service standards for safe drinking water, the run demonstrated conclusively that the unit would recover by proper field activation.

RUN NO. 4—FREQUENT DRAW-OFFS

The unit was designed to furnish drinking water which could be withdrawn in small quantities and at frequent intervals through-

out the day. Draw-offs were changed, therefore, in the next run (table 4) to correspond more nearly to actual operating conditions. Five gallons of water were removed from the pneumatic pressure tank each hour instead of the 10 and 15 gallons every two hours as in the previous runs.

TABLE 4

Super-ionite test. Run No. 4, Nov. 27–Dec. 3. Frequent draw-offs

DATE	GALLONS SINCE ACTIVATION	TOTAL BACTERIA COUNT, 37°C.			B. COLI INDEX PER 100 cc.		
		River	Effluent		River	Effluent	
			A—8 a.m.	B—4 p.m.		A—8 a.m.	B—4 p.m.
Nov. 27	25	410	850		1,000	0.0	
	65			0			10+
Nov. 28	100	1,350	100		1,000	2.0	
	140			0			10+
Nov. 29	175	150	1		10,000	0.0	
	215			1			6.0
Nov. 30	250	460	2,200		1,000	0.0	
	290			0			2.0
Dec. 1	325	60	1,000		1,000	0.0	
Dec. 2	400		240		1,000	0.0	
	440			260			2.0
Dec. 3	475	400	30		10,000	0.0	
	505			450			0.0
Average.....		470	630	118	3,570	0.29	5+

Note: B. Coli Index per 100 cc. of effluent equals number 10 cc. tubes positive times two.

The temperature of the river water dropped from 36 to 33 degrees F. during the Run No. 4 (Nov. 27–Dec. 3). The average turbidity of the raw water was 20 and the average color 21. The total count was between 60 and 1350 and the B. Coli index between 1,000 and 10,000.

The results of this run were similar to those of the previous run. The 8 A.M. samples passed the U. S. Public Health Service standards

TABLE 5

Super-ionite test with storage. Run No. 5, Dec. 5–17, 1935

DATE	GALLONS SINCE ACTIVATION	TOTAL BACTERIA COUNT, 37°C.				B. COLI INDEX PER 100 CC.			
		River	Entering super-ionite bed	Effluent A—8 a.m.	Effluent B—4 p.m.	River	Entering super-ionite bed	Effluent A—8 a.m.	Effluent B—4 p.m.
Dec. 5	105	175				1,000		0.0	
	145				10				0.0
Dec. 6	175	750		2,500		1,000		0.0	
	210				270				0.0
Dec. 7	250	300		450		1,000	10	0.0	
	285				3				2.0
Dec. 8	330			500		1,000		0.0	
Dec. 9	405	57		2		1,000		0.0	
	445				10				0.0
Dec. 10	480	1,200	245	1,850		1,000	5,000	0.0	
Dec. 11	5	500		23,000		1,000		0.0	
	40				2,300				0.0
Dec. 12	75	100	7	4,800		1,000	1,000	0.0	
	115				1				10+
Dec. 13	150	1,700		2		1,000		0.0	
	190				4,800				0.0
Dec. 14	230	1,200		900		1,000		0.0	
	265				3,400				0.0
Dec. 15	300	155		6,200		1,000		0.0	
	340								0.0
Dec. 16	375	60		2,000		1,000		0.0	
	415				5,700				0.0
Dec. 17	450	60		4,500		1,000		0.0	
	490		120		2		1,000		2.0
Average.....		521	124	3,892	1,650	1,000	(1,750)	0.0	1.3+

Note: B. Coli Index per 100 cc. in effluent equals number 10 cc. tubes positive times two.

but the 4 P.M. samples did not, although the average reduction was 99.8 percent with a minimum of 99 percent. These results indicated that additional storage should be afforded the water particularly under such conditions as prevailed here.

RUN NO. 5—EFFECT OF ADDED STORAGE

In order to determine the effect of added storage beyond that afforded by the pneumatic pressure tank when the system was operating continuously at maximum flow rate on Fox River water, the next run (table 5) was made after a 30 gallon tank was installed following the Super-Ionite column. Five gallon withdrawals were made each hour as in Run No. 4.

The temperature of the river water was between 33 and 35 degrees F. during the course of run No. 5 (Dec. 5–17). The average turbidity was 12 and the average color 24. The river water count varied between 57 and 1700 and the B. Coli index was 1,000 during the course of the run.

As before, the 8 A.M. samples of the treated water showed no B. Coli present at any time. The 4 P.M. samples showed less B. Coli than the corresponding samples in Run No. 4. Of these 4 P.M. samples, two of the eleven showed 1 out of 5 tubes positive and one showed all 5 tubes positive. The results of the analysis of the latter samples is inconsistent with the results of the others. Eliminating this one inconsistent result, the remainder conform to the U. S. Public Health Service standards for safe drinking water.

The total bacteria count of the effluent samples were higher than the total count of the raw water following the introduction of the storage tank. This might be due to the added storage time given the water or to initial contamination in the storage tank which was inserted just previous to the start of this last run.

GENERAL OBSERVATIONS

1. Super-Ionite mineral, a silver impregnated synthetic granular material, which has dropped off in its capacity for removing B. Coli as a result of severe overrun under adverse operating conditions, may be restored to normal activity by proper field activation.

2. Super-Ionite mineral, with proper storage or with reasonable draw-offs, will reduce the B. Coli concentration of the cold, highly polluted Fox River water from 1,000 to 10,000 per 100 cc. down to a concentration that is within the U. S. Treasury Department's stand-

ards for a safe drinking water. The Fox River water, during the period of these experiments, had a temperature of between 33 and 42 degrees F. and contained much foreign material in the form of fine turbidity and organic matter. The conditions therefore were about as severe as could be found.

3. The stone prefilter is a valuable adjunct in the Super-Ionite treatment because it removes suspended and organic matter which might encrust the mineral grains. Moreover, when permitted to film normally, the stone will remove some of the bacteria and raise the over-all bactericidal efficiency of the unit.

4. The total bacteria counts of the effluent samples from the Super-Ionite units were erratic over the period of these tests. An apparatus of this type frequently shows these results because of contamination in the several parts especially when frequent changes are made. When chlorine is present in the free state, casual contamination does not show up since free chlorine has a strong sterilizing effect. The Super-Ionite mineral has weak after sterilizing power. The bacteria in the effluent probably would reduce in number with continued use of the unit.

GENERAL CONCLUSIONS

According to H. W. Streeter (Public Health Reports V. 48, No. 15, p. 396) *chlorination alone* will produce a water meeting the U. S. Treasury Department standards if the B. Coli concentration of the raw water does not exceed 50 to 60 per 100 cc. in Great Lakes water and 80 per 100 cc. in Ohio River water. Super-Ionite removed at least 99 percent of the B. Coli from the Fox River water under conditions of extreme overruns, low temperature, excessive draw-offs, and highly polluted raw water.

Under all conditions, therefore, the unit may be expected to reduce the B. Coli concentration from 100 per 100 cc. to 1 per 100 cc., or to a point where the finished water meets the U. S. Treasury Department standards for safe drinking water. If one or more of the above adverse conditions is improved, the unit will reduce a larger concentration of B. Coli than 100 per 100 cc. to a satisfactory point.

Therefore, the Super-Ionite unit can be expected to purify any water which can be treated satisfactorily by *chlorination alone*. Such water would include those obtained from wells and surface supplies not heavily polluted.

THE WATER SUPPLY OF SARATOGA SPRINGS, N. Y.

By Samuel J. Mott

(City Engineer, Saratoga Springs, N. Y.)

The settlement of the City of Saratoga Springs dates to about Revolutionary days. I am indebted to Mr. John M. Corey, City Historian, for the description of the original sources of water supply.

The City of Saratoga Springs lies on two sides of a valley, the easterly side being of sandy soil and the westerly of limestone rock. On the westerly side of this valley, is a fault in the rock structure, and it is on the easterly side of this fault that all the mineral springs are located. Through this valley runs what is known as the Village Brook (now walled up and used as a surface water carrier).

The first water system of which Mr. Corey has any record was obtained from this stream. At the time of its development, the village was divided into two settlemnts, one known as the Upper Village, a settlement adjacent to the High Rock Spring (the first mineral spring discovered); the other, known as the Lower Village, consisting of a settlement near another mineral spring, known as the Congress.

The history of these various water supplies began between 1820 and 1830, when a dam was constructed over the Village Brook where High Rock Avenue (then known as Willow Walk) joins Lake Avenue, about 300 feet in the rear of City Hall. History states that this dam flooded an area as far back as Old Hodge's blacksmith shop. A wooden flume was built on the lower side of this dam which conveyed the water to an undershot water-wheel, which in turn operated a pump which pumped the water through log pipes to a wooden tank located on the easterly side of Broadway, about 300 feet north of the present City Hall. Water from this tank was conveyed through log pipes to the dwellings in the Upper Village. This simple contrivance, says the historian, was Saratoga's first water supply.

Later, Dr. Clark, who owned Congress Spring, built a dam and installed a water-wheel and pump that forced the water into a tall tower, from which it was delivered to the village through log pipes.

The historian says a charge was made for the water and, being a private enterprise, much revenue was made. As this supply was located near the Lower Village, I imagine it was only this part of the village served.

Another supply served the Lower Village, from what is known as Waterbury Brook, which flows through the northwestern section of the City. In excavating for sewers and water-mains in the westerly sections, we have uncovered the log pipes that conveyed the water from this source to the lower village.

At that early date and down to about 1846, the various water supplies were inadequate and from time to time town pumps were installed in various parts of the village, at which residents could fill pails, barrels, etc. One enterprising villager, the historian states, filled barrels from Taylor's Pond (about 700 feet west of the present pumping station) and sold the water, delivered at 12 cents per barrel.

Meanwhile, strenuous efforts were being made for a more complete water-works, and, on May 12, 1846, the first water-works bill was signed by Gov. Silas Wright; and the Trustees (of whom there were 5) turned their attention to the absorbing quest for a better water supply. The Village was empowered by law to borrow $10,000, which was loaned by John Southgate of Norfolk, Va., at 7 percent interest. On August 26, 1846, Washington Putnam, one of the earliest settlers, was given the perpetual use of water for his gift to the village of an acre on the south side of Church Street, opposite the Saratoga Golf Club, to be used as a site for a reservoir. The water supply was obtained by impounding the water flowing from several springs in the Town of Greenfield (about 2 miles west of the village.) The water from this impounding reservoir was conveyed through 6-inch sheet-iron pipes covered with about 3 inches of mortar to the open brick masonry reservoir on the Putnam lands from which it was distributed to the village. Portions of this sheet-iron pipe are still in use, serving the properties between the impounding reservoir and the westerly limits of the City. The work was completed in March, 1847, at a cost of $9,913.81, leaving a balance of $56.19. The rates were $8.00 per year.

In 1872, a law was passed authorizing the expenditure of $150,000 for a more adequate supply, at which time Excelsior Lake was purchased. This lake was created by the construction of the embankment of the Saratoga and Whitehall Railroad, now owned by the Delaware and Hudson Railroad. A Board of Water Commissioners

was appointed, and the present water supply, known as Loughberry Lake, was inaugurated. It has a tributary water-shed of 6.5 square miles, about two-thirds of which consists of level sand plains covered with a light soil. This area is covered with shallow basins, with the result that an unusual proportion of rainfall enters the ground; water losses by flood flow and evaporation being reduced to a minimum. This is indicated by the length of the overflow or spillway from the lake, which is only 14 feet in length and has served ever since the reservoir was created. This is also indicated by the small drawdown during periods of low rainfall. Never more than one-third of the effective storage volume of the lake has ever been utilized, indicating the existence of a large ground-water storage in the surrounding plains which supplies an unusual inflow during periods of low surface run-off.

The average annual draft from this supply exceeds 3.3 million gallons per day, equivalent to approximately 500,000 gallons per day per square mile of water-shed. Never since 1900, when the meters were installed, has there been a shortage of water nor has any consumer been curtailed in the use of water for lawn sprinkling, etc. The total volume of water in Loughberry Lake is 280 million gallons and the available volume 220 million gallons. The average depth is 11.3 feet and surface area at high water is 74 acres.

Evidently the first pump installed was operated by a turbine water-wheel which is still in place in the steam pumping station. Excavations show a paved head race leading from the lake to this water-wheel. From the appearance of the shafting and gears attached to the turbine, evidently a pump was located on the floor above, which pumped water to the village. It was about this time that the distribution system was installed.

Sometime between 1872 and 1883, a Knowles million and a half steam pump was installed and is now located in the steam pumping station. In 1883 a Holly-Gaskell Pump was installed. It had a capacity of 5 million gallons per day and was driven by a horizontal compound engine with high and low pressure cylinders. The water end was of the plunger type, having 672 Troy valves in the 4 compartments. This pump was dismantled in 1933 and was replaced with 2 motor-driven centrifugal pumps, designed to be installed in the present pumping station. In 1888 another Holly-Gaskell pump, of the same type, was installed. This had a capacity of 8 million gallons per day and is now standing in the steam pumping

station, which has been abandoned. This pump has 1448 Troy valves in the water end.

These pumps obtained their water from a wood crib intake, fitted with a slotted U-shaped 24-inch cast-iron pipe operated by a windlass and chains, in order to raise or lower it, to take water from any desired level. This intake was connected with the shore by a 36-inch wood stave pipe, supported by cribbing and loaded down with boxes filled with stone. At the shore end of this wood stave pipe was constructed a brick gate chamber, in which was installed a wooden sluice gate, operated by a rack and pinion. From this gate chamber, the water was conveyed by a 2-ring brick circular conduit to a suction well, from which all the pumps took their water through separate suctions.

As there was no distributing or governing reservoir, these pumps operated against the pressure in the mains and it was necessary at times of low consumption to operate a waste valve in order to reduce the pressure in the mains, and prevent stalling of the pump. The steam pressure required to operate these various units was 70 pounds.

(*Presented before the New York Section meeting, October 15, 1936.*)

TASTE AND ODOR REMOVAL AT SOUTH FALLSBURG, N. Y.

By Edward P. Schinman

(Chemical Engineer, Technical Division, The Permutit Company, New York, N. Y.)

South Fallsburg in Sullivan County, N. Y. is a summer resort town, normally having a population of only a few hundred inhabitants. During the summer, the population is conservatively estimated at 5000. The visitors, the majority of whom come from the metropolitan New York area are accustomed to a good water supply, that is, one that is relatively soft, clear and free from objectionable tastes.

The untreated South Fallsburg supply, which is taken from the outflow of Loch Sheldrake, is a creek barely 10 feet wide, which is protected, as far as possible, from pollution. The analysis of the supply is as follows:

Hardness	15 to 25 p.p.m. as calcium carbonate
Alkalinity	5 to 20 p.p.m. as calcium carbonate
Color	25 to 60 p.p.m.
Turbidity	5 to several hundred after rains
Chlorides	2 to 10 as Cl
Sulphates	5 to 10 as SO_3
Iron	0.2 to 0.6 as Fe

The treatment consisted simply of chlorinating the water, the chlorine, in the form of liquid chlorine, being added to the suction side of the reciprocating pump.

The water after chlorination had a very unpleasant muddy taste which caused a large number of complaints, not only from the year-round customers, but also from the summer paying guests. The water had a high chlorine demand and therefore there was the constant problem of adding sufficient chlorine to obtain effective sterilization and yet not produce the objectionable chlorinous tastes, due to chlorine and chlorine organic addition compounds. In this situation there was always a tendency to try to cut the chlorine dose to minimize complaints. Consequently the water company

faced the prospect of an appreciable loss of customers or had the alternative of treating the water in order to make it acceptable, as the public and consumers were becoming more "water-conscious."

The author was called in by the Superintendent Mr. Edward Teller to recommend treatment and equipment for adequate clarification and taste removal. Although several methods of treatment of this supply, based on past experience with similar waters, suggested themselves, it was realized that this was a privately owned waterworks with limited revenue. Therefore, the problem was attacked from the angle of providing simple and effective treatment which could be applied with a minimum of equipment and would require a minimum of operating cost and attendance.

The only safe method of recommending a treatment for this supply was on the basis of making actual field tests. The making of these field coagulation tests is very much simplified by the use of a portable field test kit, developed for this special purpose by the author, and which takes up no more space than a very small traveling bag.

FIELD EXPERIMENTS

The first test made was filtration through activated carbon. Several types and grain sizes of activated carbon were used and it was noted that the taste and odor were effectively removed and also that there was some reduction in color taking place while the water passed through the activated carbon.

In view of the fact that the water contains very large amounts of turbidity after rainfalls and that activated carbon cannot be called upon to take the load of color removal in addition to taste and odor removal, and since the life of the activated carbon under these conditions would be an unknown factor, it was decided that the use of activated carbon filtration should be supplemented by some form of pretreatment.

Chlorine consumption tests were run in order to determine the chlorine demand of the water. The chlorine demand measured after 30 minutes standing varied from 2.0 up to 6.0 p.p.m.

A series of coagulation tests were made in order to determine optimum conditions for color and turbidity removal. The usual jar tests were made with various dosages of alum and also noting the effect of *agitation* and *pH control.*

The alum floc formed quite readily, even without special agitation, over a wide pH range, and after filtration, the water was crystal

clear. It was therefore decided that agitation and sedimentation, which would have increased the cost appreciably, could be safely dispensed with, especially since the tests were made on the water near the season during which peak conditions and maximum pollution would prevail.

It was therefore decided to recommend sand filtration at a peak rate not to exceed 3 g.p.m. per square foot of filter bed area, during the maximum summer demand, which would correspond to approximately 2 g.p.m. per square foot maximum during the fall and winter seasons.

It was necessary to provide for the addition of alum as a coagulant, together with soda ash for coagulation and the control of the pH since after the addition of alum alone the water would have a relatively low pH value.

The effluent of the sand filters, after pH adjustment, was to be passed through special acid treated activated carbon of approximately 4–30 mesh material. In the use of activated carbon in granular form for pressure filtration, it is desirable to keep the grain size large for mechanical reasons, but not too large so that it would adversely effect the ultimate life or capacity of the activated carbon bed.

EQUIPMENT

On the basis of a peak rate of 200 g.p.m., two 78-inch diameter Type F. Permutit sand filters were installed. There were special features regarding these filters in that one single multiport control valve was used in order to control the operation of the two units. The type of strainer system used, while it has been used for some time in industrial practice, is relatively new in the waterworks field. Field tests have shown this type of strainer system is superior to the usual header, lateral, nozzle type and also reduces the amount of wash water required. The layers of filtering material were as follows:

15 inches fine sand, effective size 0.5 mm., uniformity coefficient 1.6.
7 inches coarse sand, effective size 1.0 mm., uniformity coefficient 1.6.
4 inches, $\frac{1}{4}$ x $\frac{1}{8}$ inch gravel.
4 inches, $\frac{1}{2}$ x $\frac{1}{4}$ inch gravel.
8 inches, $\frac{1}{2}$ x 1 inch gravel.
6 inches, 1 x $1\frac{1}{2}$ inch gravel.

The type of chemical feed selected was the double orifice, pressure solution, displacement type in which a known weight of chemical is dissolved in an automatically measured definite volume of water. With this type of feed, the feeding of a solution of known concentration is accomplished in proportion to the flow of water. The feed is varied merely by adjusting the indicating needle valve.

The method of application of the chemicals was worked out in coöperation with the New York State Board of Health and the chemical feeds were installed so that the alum for coagulation could be added at the suction side of either of the service pumps or ahead of the sand filters on the discharge side of the service pumps. The soda ash can be added ahead of the filters so as to react with the alum when necessary or can be added after coagulation and sand filtration for pH correction.

There was some question as to the selection of the size of the activated carbon filter. It was desirable to have it fit into the available space in the pump room. The important factor in the selection of activated carbon filter size was the consideration of the necessary time of contact to accomplish dechlorination and taste removal. In order to maintain uniformity of filter size and to keep within the space available, it was decided to use a 78-inch diameter unit with an extra deep bed of activated carbon, approximately 60 inches in depth.

In order to prevent corrosion of the steel shell when in contact with the activated carbon, the taste and odor removal filter was lined with a special bitumastic enamel which would not impart any extraneous taste to the water. The same type of strainer system was used in the activated carbon filter as for the sand filters.

Before the water treatment equipment was installed the water was pumped by Diesel driven triplex pumps to service and to an elevated storage tank which floats on the line. While the treatment equipment was being erected, a new Worthington triplex pump was installed, the old pump being used for standby service.

OPERATION OF PLANT

The method of operation was worked out during a conference with Director C. A. Holmquist, Associate Director Earl Devendorf, Senior Sanitary Engineer, R. D. Bates and District Field Engineer, W. H. Larkin of the New York State Department of Health. The water is super-chlorinated to maintain a residual of approximately

0.5 to 0.8 p.p.m. in the effluent of the sand filter. Alum is added, under normal operation, on the suction side of the pump, in sufficient quantities to obtain a color of approximately 10 or less at the filter outlet.

A convenient check for noting the amount of alum used is made by titrating the water before and after the addition of alum and noting the reduction in alkalinity. One grain per gallon of alum sulphate will reduce the methyl orange alkalinity 8 p.p.m. and other quantities of alum will reduce the alkalinity proportionately. Also, the addition of 1 grain per gallon of alum will increase the CO_2 content 6 p.p.m.

If the water after alum addition has too low a pH value for effective coagulation, or there is not sufficient natural alkalinity in the water to react with the alum added, soda ash is added before the filter to provide alkalinity and adjust the pH value for coagulation.

The water, after the addition of alum, has a very low alkalinity and soda ash is therefore added, at the outlet of the filters, in order to raise the pH to approximately 7.5 to 7.6.

The water after coagulation and sand filteration is passed through the activated carbon filter to service and the elevated storage tank. The sand filters are washed when the pressure loss through the bed is approximately 8 to 10 pounds per square inch. The loss of head through the activated carbon bed is negligible, but washing is carried out periodically once a week at a wash rate of 6 g.p.m. per square feet which, with this particular activated carbon, provides for a bed expansion of 50 percent.

RESULTS OBTAINED

A check run on the operation of the plant was made on October 9 under the supervision of Mr. J. E. Kerslake of the New York State Department of Health and the details of this test run are given in table 1.

Various dosages of chlorine varying from approximately 2 to 6 p.p.m. were used. Although the color of the raw water is only 35, it required 3 p.p.m. of chlorine to obtain a residual of 0.5 p.p.m. after the sand filters. It is interesting to note that with the high amounts of chlorine applied there appeared to be some bleaching action of the chlorine on the color. The larger amounts of chlorine also assisted coagulation as evidenced by the lower color in the plant effluent.

B. coli were present in the raw water sample, but were absent in all of the treated water samples taken after the sand filters and the activated carbon filter.

With the various chlorine dosages used, the chlorine content of the sand filter effluent varied from 0.1 to 1.6 p.p.m. and regardless of the variation, the effluent from the carbon filter showed zero chlorine. The effluent of the carbon filter was also free from objectionable chlorinous tastes. Under present conditions any desired amount of chlorine can be applied in order to obtain effective sterilization without causing complaints due to chlorinous tastes.

The chlorine is determined by means of the regular Orthotolidin test. The methyl orange alkalinity and the CO_2 are determined by

TABLE 1

Results of test run, October 9, 1936

SAMPLING POINT	SAMPLE 1 RAW WATER	SAMPLE 2 EFFLUENT SAND FILTERS	SAMPLE 3 EFFLUENT CARBON FILTER
Color	35	22	10
Turbidity	5	0	0
Iron as Fe	0.4	0.2	0.1
Hardness as $CaCO_3$	18	18	18
Oxygen consumed	3.1	3.4	1.1
Residual chlorine		0.5*	0.0
B. coli	Positive	Negative†	Negative†

Alum dosage 0.4 g.p.g.

* Applied dosage 3.0 p.p.m. Residual after 5 minutes standing 0.85.

† All samples.

the usual method of titrating with N/50 sulphuric acid and N/22 sodium carbonate and by, from the relation between the methyl orange alkalinity and the CO_2 the pH value is read from a chart. All the test equipment is enclosed in a cabinet to protect it from dust, etc.

The superintendent was instructed in the manner of making the simple jar coagulation tests to determine the proper treatment should the water not respond readily to the treatment provided. Up to this time, it has not proven necessary to make these jar coagulation tests.

The operation of the plant is being carefully watched by the New York State Board of Health in order to provide the usual protection

to the municipality and also to obtain data on this economical plant which may be considered for other smaller communities which are not able to afford more elaborate plants, but still want the best water possible from the existing supplies.

(*Presented before the New York Section meeting, October 15, 1936.*)

EXPERIENCES IN WELL CONSTRUCTION

By J. A. Carr

(*Superintendent, Water Department, Ridgewood, N. J.*)

My remarks will be confined to the drilling of wells in rock, that being the type of well with which I am most familiar.

In my opinion the most important points in the construction of a new well are:

1. Full and complete specifications and a bid sheet permitting a fair comparison of prices
2. The selection of a responsible contractor
3. A plumb, full size hole
4. Proper sealing
5. Proper and complete testing

(1) The preparation of specifications for drilling a hole in the ground would seem to be a simple matter. In my opinion it is not as simple as it first appears. There are several points both in the specifications and in the bid sheet which may cause difficulty in deciding the low bidder and misunderstanding in making payments. These points should be clearly set forth in fairness to both the contractor and the purchaser.

We, in Ridgewood, do not contract for a flat sum to a fixed depth, but call for bids by the foot. For instance, our bid sheet reads as follows:

Item 1. For drilling, furnishing, setting and sealing, both a —— inch and a —— inch casing from the surface of the ground to rock, as specified for $—— per lineal foot.

Item 2. For drilling a —— inch well from the bottom of the casing to a point 150 feet deep for $—— per lineal foot.

Item 3. For drilling, etc. —— from a point 150 feet deep to a point 250 feet deep for $—— per lineal foot.

Item 4. For drilling, etc. —— from a point 250 feet deep to a point 500 feet deep etc.

Usually the most expensive portion of the well is the portion which is cased down to and into rock. The depth into rock to which the casing will be carried cannot always be decided in advance. In order

that all bids, therefore, may be considered on an equal basis, the following statement is made in the specifications: "For the purpose of comparing bids the distance from ground surface to rock will be considered to be —— feet." The distance mentioned is the approximate depth we believe the rock to be.

Our specifications provide that we may stop drilling at any depth. Again so that bids may be comparable, we state in our specifications, "While the contractor's bid is based upon a maximum depth of 500 it is distinctly understood that drilling may be stopped by the Engineer at any depth, however, it is guaranteed that the contractor shall be paid for at least 200 feet of drilled well."

We provide that the well shall be tested once by and at the expense of the contractor, but also, that more than one test may be required. So that any uncertainty in bidding as to additional tests will be removed, the specifications set up the amount to be paid to the contractor for such additional tests. This set up price is on an hourly basis.

(2) Next after the receipt of bids is the selection of a skilled and experienced contractor. The selection of a responsible contractor, one who is not only responsible financially, but more important one who knows how and has the equipment to do a first class job, and also the desire to do it.

The improper care and use of drilling tools and improper handling of casings may result in defective wells causing much immediate or future trouble and expense.

There should be absolute insistence that the contractor's representative on the job, who is usually the rig operator, keep proper records and turn over to the purchaser full and complete information as to what is being done, and what is happening as the work progresses. Samples of drillings at various depths should be preserved.

Unfortunately, there are still some drillers who think their operations are secret. They should be impressed with the fact that there are two parties, the owner and the contractor, who should know all there is to know about the hole. Full and accurate records are most essential for the proper future operation of the well.

(3) The hole should be started at a size sufficient to permit as many reductions in diameter as may be necessary and still have ample diameter for pump installation and to permit future work or alterations.

We recently had occasion to insert a 10-inch casing in a well that

had already been reduced from 16- to 12-inch. Had the hole been started smaller it might have been necessary to abandon it. It is poor economy to drill small holes.

The well should be plumbed and gauged at frequent intervals during drilling in order that the purchaser may be assured a straight plumb hole of the required size. Watching the cable to see that it hangs in the center of hole is a rough check for plumb. The bits should be frequently checked to see that they are the full diameter required.

While a hole straight but slightly out of plumb does not interfere to any great extent with a pump setting, a zig zag or cork-screw hole can cause no end of trouble and expense. This fact was vividly demonstrated to us recently when we inserted a 10-inch inner casing in an old 12-inch well. The casing above rock was out of plumb and there was a constriction in diameter of the rock hole which it was necessary to correct before the 10-inch could be entered.

(4) There is only one sure and permanent way of sealing a rock hole to shut off surface or top ground water and that is by double casing, with the annular space between the two grouted with neat cement.

On new holes we require the outer casing to be driven to the rock. The drilling is then continued the same size as the outer casing to a depth equal to the length of the string of tools past all soft or broken formation. The hole is then filled with sand to a point where the inner casing is to set.

The balance of the hole is then partially filled with neat cement. A cast iron plate is welded over the end of the inner casing and it is lowered and pushed into the cement to the required depth. This gives the inner casing a piston action forcing the cement around the bottom of the casing, and up into annular space between the two casings. The balance of the space is filled with cement to the top. After the cement has set for several days the cast iron plate is knocked out, the sand bailed out of the hole, and drilling is continued into rock.

The purpose of the sand is to permit the string of tools to hand out of the casing when drilling is resumed in order to avoid jarring and cracking the cement.

When inserting an inner casing in old wells, the hole is bridged at the required depth and the same procedure followed.

In placing the cement in the well considerable care is necessary, because if the cement is put in dry it has a tendency to bridge before

reaching the bottom and not entirely filling the annular space. We have found it most satisfactory to mix the cement with water to the consistency of heavy cream and to pour it in. Whether or not the space is entirely filled can be roughly checked by computing the volume of cement required.

If the cement is placed dry, a small pipe carrying air from a compressor should be lowered to the required depth and gradually withdrawn as the hole fills. By this means the bubbling air prevents bridging of the cement.

(5) Tests should be made with a pump of sufficient capacity to handle more water than is expected, and with the pump set low enough to secure a maximum draw down. The yield should be measured either by meter or orifice. We do not favor testing with air.

On all wells we require a 72 hour test of continuous pumping. For the first 60 hours the well is pumped to capacity at a maximum draw down. Usually after the first twelve or fifteen hours a point is found where the level does not change and the well is pumped at that level until about the sixtieth hour. The pumping rate is then gradually reduced by degrees, at intervals of about an hour and the draw down at different rates noted. This method gives a very good record of the capacity of the well at different draw down levels and its rate of recovery. By this method the proper pump setting can be chosen. It sometimes happens that a well will not yield enough more at, say for example, 125 feet than at 75 feet to make it worth while to pump against the additional head.

We prefer, as being more positive, this method of pumping to capacity first and then slacking off, to drawing the well down gradually. If a well recovers to a certain yield and draw down after being pumped for 60 hours in excess of that amount, it is reasonably certain that it will maintain that capacity at that draw down under ordinary service conditions.

While tests are being carried on hourly, readings are taken on all surrounding wells available, both public and private, within a half mile radius.

In concluding, may I call your attention to the fact that several states are licensing well drillers and have adopted well drilling codes. I understand such a bill is now in committee in Trenton. It is known as Senate Bill No. 55 and was drafted by the New Jersey Division of the American Association of Well Drillers. This bill

provides for state supervision of all well drilling and the licensing of all well drillers. The bill is a decided step forward toward the securing of competent drillers and properly constructed wells. The bill merits the support of this Association both individually and collectively.

(Presented before the New Jersey Section meeting, October 23, 1936.)

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the journal.

Ponce City, Oklahoma, Replaces Wells with New Surface Supply. The American City, **51**: 7, 43–44, July 1936. Continually increasing hardness and salinity of water from wells in the vicinity dictated their abandonment. Instead, water from reservoir formed by two dams on nearby creeks is pumped to treatment plant, where it is coagulated and filtered.—*Arthur P. Miller.*

City Studies Water Revenues. Turns to Universal Metering. The American City, **51**: 7, 67–71, July 1936. Under incentive of increasing deficits in Water Department, city of Manistique, Michigan, compared their water consumption with that of similar cities, and after carefully computing costs and revenues, decided that 100 per cent metering would be profitable. Results to date have justified this decision.—*Arthur P. Miller.*

California Municipal Water Supplies. CHARLES G. HYDE. The American City, **51**: 6, 67–70, June 1936. Statistical résumé of data from report by California State Department of Public Health for years 1930–1932, giving number of water supply systems and districts, their ownership, their water consumption and treatment methods; together with descriptions of some of more outstanding examples.—*Arthur P. Miller.*

Handling 9,000 Water Accounts. N. V. Moss. The American City, **51**: 6, 72–73, June 1936. Description of methods used for meter reading and billing in Amarillo, Texas.—*Arthur P. Miller.*

Unusual Design for Elevated Storage Tank. FRANK H. CLOUGH. The American City, **51**: 6, 75, June 1936. This 150,000-gallon tank in residential area in South Pasadena, California, was designed to comply with requirement that it should combine beauty to harmonize with surroundings with structural stability to meet the earthquake hazard. Symmetrically semi-parabolic, it is supported, without a platform, by eight built up columns.—*Arthur P. Miller.*

Wisconsin's Well-Drilling Code. FRANK R. KING. The American City, **51**: 6, 80, June 1936. Description of recently enacted law designed to safeguard potable supplies from wells.—*Arthur P. Miller.*

The Water-Softening Plant of Hamilton, Ohio. The American City, **51**: 6, 87–88, June 1936. Description of plant, with equipment for lime application, clarifying, filtering, recarbonating, chlorinating, and pumping.—*Arthur P. Miller.*

Silting of the O'Shaughnessy Reservoir. A. M. EDWARDS. Civil Engineering, **6**: 8, 511–512, August 1936. Columbus, Ohio, obtains part of its water supply from the O'Shaughnessy reservoir on the Scioto River. For 298 days in 1934 there was no flow over the spillway and water-level fell to 36 feet below the crest. This exposed a great expanse of silt, revealing considerable loss of capacity. Survey showed that in nine years reservoir had silted up 6.1 per cent of its capacity. By contrast, silt surveys of several municipal water supply reservoirs in Texas have shown rates of from 2.0 to 2.4 per cent per year.—*H. E. Babbitt.*

Trends in Water Works Practice. M. F. TRICE. Civil Engineering, **6**: 8, 520–523, August 1936. Among recent improvements which have taken place in water works practice may be included:—use of newly introduced chemicals for better flocculation and for elimination of tastes and odors; increased efficiency of sand filter beds due to higher rates of backwashing; and prolongation of chlorine disinfecting action through addition of ammonia. Activated carbon has proven effective in removing taste-producing constituents of vegetable and animal origin. A mechanical aid to flocculation has been provided which greatly improves efficiency of chemicals. It has been shown also that a clean sand filter bed will produce a better effluent than the ripened filter previously favored in water purification plants. Trend in storage of water is toward elevated rather than ground storage, and towards beauty in design.—*H. E. Babbitt.*

Constructing Village Water Works and Sewers. E. A. LAWRENCE. Civil Engineering, **6**: 8, 506–510, August 1936. Water and sewer problems encountered in villages are probably even more diversified than like problems in cities, and almost always require experience and sound judgment to secure the best results. In cities where experienced legal departments are maintained, engineering department can usually confine its efforts to purely engineering aspects of the various projects for which plans are required. In villages, on the other hand, the consulting engineer is almost forced to assist in solving financial and legal problems. The engineer for the village improvement is called on to play the rôle of gambler de luxe, as he must rely upon willingness of the electorate to approve the project and upon good faith of the village council to legalize terms previously agreed upon. Among technical problems encountered may be included: minerals in raw water, iron-removal plants, fluorine in water, problems of quantity of water available and required, development of wells, types of well pumps, securing of surface water supplies, construction of dams, design of spillways, proper provision for fire fighting, layout of distribution system, elevated storage tanks, and concrete reservoirs. Much that has been said about water supplies in villages applies equally to sewers and sewage treatment plants.—*H. E. Babbitt.*

Lead Pipes as a Source of Lead in Drinking Water. G. N. Quam and A. Klein. Journal American Public Health Association, 26: 5, 778–780, August 1936. Samples of water from sources supplying the City of New York have been permitted to remain in contact with lead pipes for varying periods of time. A lead concentration as high as 4.722 p.p.m. is reported to have been attained after 14 days exposure.—*H. E. Babbitt.*

Analysis of Flow in Networks of Conduits or Conductors. Hardy Cross. Bulletin No. 268, Engineering Experiment Station, University of Illinois, November 13, 1936. The problems deal primarily with systems carrying water and incidentally with those carrying electric currents. In general, the analysis of such systems by formal algebraic procedures is, if the systems are complicated, very difficult. Models have been used, but here, as elsewhere, there are some objections to their use. The methods here presented are methods of successive corrections and thus involve an arithmetical application of the fundamental principle of the differential calculus. In the problem, as usually presented, the quantity of fluid or of energy flowing into distribution system at one point is known and the point, or points, of delivery are also known. Sizes and lengths of conductors, or pipes, in system are given or assumed, and also the law controlling relation between quantity of flow in the conductor and loss of head, or voltage, in a given length. It is usually desired to determine total loss of head, or voltage, between inlet and outlet. Two methods of analysis are proposed. Principle of one of these is that flows in pipes, or conductors, of network must always satisfy the condition that total flow into and out of each junction is zero. Principle of the other is that total change of head around each circuit always equals zero; and flows in pipes of circuit are successively adjusted, so that total flow into and out of each junction finally approaches, or becomes, zero. The five steps in the method of solution of the problem in a known distribution system are:—(1) Assume any distribution of flow. (2) Compute in each pipe the loss of head, $h = rQ^n$. With due attention to sign (direction of potential drop), compute total head loss around each elementary closed circuit, $\Sigma h = \Sigma rQ^n$. (3) Compute also in each such closed circuit the sum of the quantities $R = nrQ^{(n-1)}$ without reference to sign. (4) Set up in each circuit a counterbalancing flow to balance the head in that circuit, equal to

$$\Delta = \frac{\Sigma rQ^n \text{ with due attention to direction of flow)}}{\Sigma nrQ^{(n-1)} \text{ (without reference to direction of flow)}}$$

so that $\Sigma r(Q - \Delta)^n$ will equal zero. (5) Compute the revised flows and repeat the procedure. Continue to any desired precision. Proof of accuracy of the method and illustrative problems are given.—*H. E. Babbitt.*

Restoration of Ground Water Levels and Lake Levels in Wisconsin. H. W. Mead. Bulletin of the Associated State Engineering Societies, 11: 3, 37–40, July, 1936. The work of restoring ground water levels and lake levels has been one of the important state-wide programs under both WERA and WPA. This work is divided into two divisions; the control of the flow of water in the Central Wisconsin drainage districts, and the restoring of lake levels.

Low, flat land, consisting principally of peat soil, has been ditched, with ditches ranging from 6 to 20 feet wide. These ditches were controlled by construction of small dams, raising the ground water level and bringing the land back to its natural state.—*H. E. Babbitt.*

Roller Gates. W. Z. LIDICKER. Bulletin of the Associated State Engineering Societies, 11: 3, 52–68, July, 1936. A roller gate is a cylindrical steel structure placed in a horizontal position between two concrete piers. The drum is strengthened by longitudinal ribs and stiffered by transverse bracing at intervals of 8 to 10 feet. Attached to each end of the drum is a cast steel gear rim engaging a similar set of teeth in a rack set in the pier. The concentrated load of the teeth and track is distributed throughout the drum shell by a heavy steel plate called the load disc. At one end of the roller gate a chain wraps part way around and is anchored to the drum, the chain extending to the operating machinery for the gate which is placed on top of the pier. At each face of the pier the drum has attached to it a flexible steel plate called the end shield to cover the recess in the pier and provide a water seal around the ends. Near the bottom of the drum and somewhat upstream, is a curved apron which projects below the bottom of the drum. This increases the height of the gate and allows the drum to be submerged. This apron is rigidly attached to the drum. The primary advantages of the roller gate are: 1st. the long gate lengths economically feasible; 2nd. abundant vertical rise to give adequate clearance above high water, and 3rd. a ruggedness of structure and record of dependability and long service in severe winter conditions. The roller gate was invented in Germany about 35 years ago, and has been much used in that country and Scandinavian countries ever since. The designing of the roller gate may properly be divided into: 1st. the determination of the size, shape, and characteristics of a gate which will satisfy the requirements of a given project in the most economical manner; and, 2nd. the analysis of the gate to determine the stresses and sizes of the members required. The article proceeds to discuss each of these divisions of design. The cost per square foot of roller gate in place was approximately $120 for Dam No. 8 on the Upper Mississippi River. A similar figure for 35- x 15-foot Tainter gates was about $100. Discussion by C. R. MARTIN, p. 58. **Mechanical and Electrical Features.** J. C. BABSON, p. 60. The type of machinery used in the operation of the roller gates is massive in design when compared with other operating machinery that is installed at locks and dams. The roller gates are raised and lowered through a hoisting mechanism placed at the top of the pier. In general, this machine is a large chain hoist that raises the gate by a chain wound part way around one end of the drum. The hoist is driven by an electric motor that is in turn controlled by two multiple contact limit switches working in conjunction with a full magnetic controller, all of which is controlled from a master switch that is located at one end of the hoist. The driving motor is a wound-rotor induction type, direct connected by a flexible coupling to the extended high speed work shaft of the speed reducer. There are three 3-kw., 440-volt, 60-cycle, single-phase heaters, connected in delta and installed in each end of the roller gate drum directly on the end discs, for the purpose of melting

ice that may have formed in the pier recesses. Discussion by C. R. MARTIN, p. 67. In all designs, the engineer considers what will happen in case apparatus does not function. With the roller gate operating machinery, this has been given careful attention, as some features incorporated in present gates are new in application and in the size of parts.—*H. E. Babbitt.*

A Simple Apparatus for Pouring an Exact Quantity of Agar into Plates Aseptically and Free from Foam and Bubbles. EINAR LEIFSON. Jour. Bact., 30: 4, 423, October 1935. 4 pages.—*Ralph E. Noble.*

The Metabolic Activity of Various Colon-group Organisms at Different Phases of the Culture Cycle. GRACE MOONEY and C.-E. A. WINSLOW. Jour. Bact., 30: 4, 427, October 1935. 15 pages.—*Ralph E. Noble.*

A Comparison of the Eijkman Test With Other Tests for Determining Escherichia Coli in Sewage. A. A. HAJNA and C. A. PERRY. Jour. Bact., 30: 5, 479, November 1935. 6 pages. Standard lactose broth and certain proposed substitutes have been compared with the authors' modified EIJKMAN medium as to their relative efficiency in isolation of *E. coli* from raw sewage. The EIJKMAN test was found superior to standard lactose broth, buffered lactose broth, RITTER'S, SALLE'S, DOMINICK-LAUTER'S, and STARK'S and ENGLAND'S broths in number of isolations made and in gas tubes confirmed for *E. coli*. In further comparison between standard lactose broth and modified EIJKMAN broth for the isolation of *E. coli* from raw sewage, sewage effluent, and sludge, *E. coli* was recovered from more tubes of EIJKMAN broth than of lactose, except in case of sewage sludge, where 4.5 percent more lactose tubes confirmed. A much larger percentage of EIJKMAN tubes with gas confirmed in all instances.—*Ralph E. Noble.*

Iodoform Odor in Iodine-Containing Mineral Water. E. LINDNER. Chemiker Zeitung, 60: 42, 426, June 1936. In water from a Hungarian thermal mineral spring containing 0.1 p.p.m. of iodine, which is saturated with carbon dioxide and bottled under pressure of 85 pounds per square inch, occasionally, after prolonged storage, iodoform odor develops. Tests have shown that oxidizing agents will cause iodoform formation provided suitable organic matter is present. It is supposed that the juvenile water rising from the Hungarian thermal fault becomes contaminated in passage through the upper strata with ground water carrying nitrites and with sulphur-oxidizing bacteria; iodoform formation being promoted by low hydrogen ion concentration.—*Manz.*

Water Treatment for Swimming Pools (Indoor and Outdoor). OTTO ULSAMER. Gesundheitsingenieur, 59: 26, 402, June 1936. Review of current methods of treating pool water, with special reference to avoidance of chlorine troubles. To precipitate chlorine-binding organic matter and thereby minimize chlorine dose, recirculation and filtration of pool water, often with coagulation as well, are indispensable. For elimination of chlorinous taste and odor, combined methods such as chloramine, or hypochlorous acid (free-

dom from hydrochloric acid secured by percolation through marble tower), have proven more successful than chlorination alone. Good results in control of algae growth are obtained by treatment with chlorine and copper (as applied at Olympic stadion at Berlin), with copper dose ranging from one-tenth to one-twentieth of that of chlorine; or with chlorine and silver, with silver doses ranging from 30 to 80 milligrams per cubic meter; or with combined chlorine-copper-silver-treatment, with from 100 to 150 milligrams copper and 10 to 15 milligrams silver per cubic meter. In opinion of the author who is a member of the Prussian State Institute for water, soil, and air hygiene, safe conditions are secured with negative coli-test in 100- to 10-ml. samples, agar plate counts not exceeding 100, and gelatine counts not exceeding 500; these bacteriological standards being maintained with chlorine residual of pool effluent approaching negativity to iodine-starch test, but positive to benzidine test. For outdoor pools, a lower range of bacteriological quality is permissible; but except in times of flood, *Bact. coli* should not be present regularly in samples of 0.01 ml.—*Manz.*

Biology of Water Supplies. LEO MINDER. Schweiz. Verein von Gas- und Wasserfachmännern, Monatsbulletin **16**: 5, 102, May 1936. Review of occurrence and of sanitary significance of, and of protective measures against, organisms in water supplies. Of the iron bacteria, crenothrix is but seldom, leptothrix and gallionella frequently, recorded; growth being promoted wherever steel plate, cast iron pipe, etc. come in contact with iron-free water; corrosion of metal underlying bacterial film is remarkable. Red water trouble at Wettingen, due to solvent action of oxygen-free ground water on distribution system, was overcome by preliminary pressure aëration; but further difficulties have since arisen from luxuriant growth of a zooglœa-forming coccus, covering entire inner surface of pipes and imparting to the water an unpleasant odor of decomposition. It has not yet been possible to trace the origin of this growth, or to eradicate it; it is believed that an unusually great increase in water temperature (from 5° to 17°C.) during last summer enhanced the growth. Supplies originating from deep lakes are to be considered satisfactory; although a distinct fishy odor is often noticeable during summer at the bridges over the Limmat, which is the outflow from the lake, in the city of Zurich, no odor was ever imparted to the city supply. Rapid sand filters should retain suspended matter down to 5μ size with an average efficiency of 90 percent. Investigations of Zurich slow sand filters showed no increase of bacterial count after cleaning and absence of bacteria-destroying organisms, with counts quickly decreasing towards deeper layers. Decrease of dissolved oxygen during filtration is regularly recorded and averages 0.47 ml. per liter, the observations extending over ten years. This may be interpreted as due to respiration and living activity of the filter. Chemical examination shows a decrease in oxidizable matter and in ammoniacal nitrogen, with approximately corresponding increase of nitrate nitrogen, indicating oxidative destruction of organic matter resulting from bacterial activities.—*Manz.*

Magno-Filter-Material. OSKAR RITSCHEL. Deutsche Licht- und Wasserfachzeitung, 30: 15, 330, 13, July 1936. Very soft waters (up to approximately

35 p.p.m. hardness) may be filtered over pure burnt magnesite; but with hard water cementing of grains takes place, due to deposition of calcium carbonate during time of reduced flow. Magno-filter material is partly burnt dolomite, analyzing 71 percent calcium carbonate, 22 percent magnesium oxide, and 3 percent magnesium carbonate; burning procedure being directed to calcine magnesium carbonate as far as possible without attacking calcium carbonate, since even a small percentage of calcium oxide may impart to water persistent alkaline taste. Magno-material proved effective for deacidification under widely varying conditions, alkalinity of water to be treated not being limited to calcium carbonate equilibrium conditions. Iron and manganese are simultaneously removed.—*Manz.*

Cumasina Process on Plant Scale for Water Sterilization for Drinking, Bathing, and Industrial Use by Means of Silver. WALTHER KRUSE and MAXIMILIAN FISCHER. Gesundheits-Ingenieur, **59**: 22, 312, May 1936. Under the title of Cumasina process, electrolytic disinfection of water, using either silver or insoluble anodes, is claimed. Germicidal effect of special Cuma process with anodic formation of dispersed active silver chloride is explained. Method has been used for some years in municipal pool at Leipzig and has given uniformly negative coli tests in 100 ml. and, except for occasional appearance of silver-resisting forms, low bacterial counts. With current consumption of 1.25 amp. at 9 volts, 1 kg. silver is dissolved after 3 to 4 weeks. —*Manz.*

Tastes and Odors. Causes and Prevention. L. C. BILLINGS. Southwest Water Works Jour., **18**: 3, 21–22, 1936. A list of algae giving trouble in Texas and a discussion of the methods of treatment are given.—*O. M. Smith (Courtesy Chem. Abst.).*

Water Main Jointing Materials; Experience with Cement. FRANK M. MURPHY. Southwest Water Works Jour., **18**: 4, 15–16, 1936. Cement makes as good a joint as other material and costs less. Methods of use are given.—*O. M. Smith (Courtesy Chem. Abst.).*

Suggested Water Works Standards. CHARLES M. CRAWFORD. Southwest Water Works Jour., **18**: 4, 22–23, 1936. Detailed résumé of operating standards for state of Texas is given. Maximum permissible limits are:—for total solids, 1000 p.p.m.; for chloride, 400 p.p.m.; and for sulfate, 350 p.p.m.—*O. M. Smith (Courtesy Chem. Abst.).*

Contamination of Well Water Supplies. EARNEST W. BOYCE. Southwest Water Works Jour., **18**: 6, 11–13, 1936. Discussion of causes of contamination and of specifications and regulations of Health Department of Kansas.—*O. M. Smith (Courtesy Chem. Abst.).*

Amarillo's Customers' Accounting. N. V. MOSS. Southwest Water Works Jour., **18**: 6, 14–15, 1936. Description of methods followed.—*O. M. Smith.*

Ground Water Resources of Texas. A. H. DUNLAP. Southwest Water Works Jour., 18: 6, 16–17, 1936. Brief survey, with excellent bibliography, is given.—*O. M. Smith (Courtesy Chem. Abst.).*

Soil Conservation in Regard to Water Supplies in the Southwestern States. G. A. BARNES. Southwest Water Works Jour., 18: 5, 11–14, 1936. Underground reservoirs are filling at rate of 0.34 to 2.43 percent per year, depending upon character of soil and condition and extent of watershed.—*O. M. Smith (Courtesy Chem. Abst.).*

Distribution System Maps and Records. C. E. PERKINS. Southwest Water Works Jour., 18: 5, 15–16, 1936. Description of methods used by town of 15,000 population.—*O. M. Smith.*

Factors to Be Considered in Making Rates. MARVIN C. NICHOLS. Southwest Water Works Jour., 18: 2, 13–15, 1936. A good brief outline.—*O. M. Smith.*

Tastes and Odors; Their Measurement and Control. JOHN P. HARRIS. Southwest Water Works Jour., 18: 3, 12–15, 1936. Excellent brief summary of present knowledge.—*O. M. Smith (Courtesy Chem. Abst.).*

Materials, Installation, and Maintenance of Service Pipes. MARVIN TURNER. Southwest Water Works Jour., 18: 3, 16–17, 1936. Recital of experiences at Austin, Texas. Much trouble may result from materials not being suited to prevailing soil and temperature conditions and from incorrectly sized services.—*O. M. Smith.*

Structural Properties of Vibrated Concrete. PAUL ANDERSON. Eng. News-Rec., 115: 676–7, 1935. Tests, the results of which are given, indicated (1) that the water-cement ratio law holds for very lean mixtures, provided a compact concrete can be produced, and (2) that the shrinkage of lean mixtures when compacted by vibration is considerably less than that of richer mixtures of same water-cement ratio.—*R. E. Thompson (Courtesy Chem. Abst.).*

Overtopping of Small Dam Causes Flood in Italy. E. PROBST. Eng. News-Rec., 115: 607–10, October 31, 1935. Illustrated discussion of failure of Alla Sella Zerbino Dam (12 meters high) above Molare in Northern Italy on August 13, 1935, following succession of intense rains of cloudburst character. More than 100 lives were lost. Dam, together with larger one, Zerbino (42 meters high), formed Ortiglieto Reservoir on Orba River, which provided storage for power plant supplying Genoa. Structure was of gravity design and is believed by author to have been constructed of Cyclopean concrete. DUBOIS (Bull. Téchnique de la Suisse Romande, August, 1935) concludes that overloading and possible absence of safeguards against underscour caused collapse of dam. PROBST appears to have reached similar conclusion. In discussion by ROBERT A. SUTHERLAND, it is pointed out that failure of small dam would release almost half of water in reservoir at normal water

level, i.e., 8 out of 18 million cubic meters, and with water level 5 meters above normal, 14 out of 24 million. Potentiality for disaster was therefore far greater than its comparatively small height would indicate. Flood runoff, estimated by PROBST at 1,377 second-feet per square mile of catchment area (58 square miles), is extraordinarily high. Only record approaching this figure is that cited by CREAGER and JUSTIN in Hydroelectric Handbook, page 48, for Devil's Stream, Iowa: 1300 second-feet per square mile on catchment area of 143 square miles.—*R. E. Thompson.*

Grouting Checks Leakage in Earthfill Dam. E. M. WILBUR. Eng. News-Rec., **115**: 499–500, October 10, 1935. Repair of earth dam of Port Jervis, N. Y., water department by grouting is described. Success of work is believed to have been established by more than 7 months of satisfactory service under repeated full head. Old dam, impounding small mountain creek, was built in 1887 with team and hand labor. It was about 40 feet high and was composed of miscellaneous borrow with high proportion of cobbles and boulders. Impervious section consisted of clay facing, about 3 feet thick at water line and probably thicker below. In defiance of most accepted present-day principles of design, dam remained in fairly satisfactory service for 45 years. In 1930, city purchased water system from company and in 1932 dam was raised about 8 feet to provide 6 feet additional storage depth at cost of about $40,000. No borings were made. When reservoir filled following spring, alarming leakage broke through. Local repairs were made, but following year water again broke through. Blanket fill of rolled earth was rejected owing to cost and it was decided to make wash borings to impervious stratum and seal fill in front of corewall and sheeting (placed when dam was raised) with earth and cement grout. Pumping outfit consisted of horizontal double-action hand force pump. Mixture of cement and soil varied from 1:2 to 1:6. Overall cost was about $17,000. Experience showed that little effect is obtained in sealing voids in porous earth strata below bottom elevation of grout pipe. They must be worked from bottom up.—*R. E. Thompson.*

New Hampshire Water Board Outlines Conservation Plan. Eng. News-Rec., **115**: 600, October 31, 1935. New Hampshire Water Resources Board was created in 1935 to carry on comprehensive program of water conservation. Board, consisting of 5 members, was organized as corporation and is empowered to issue bonds and collect fees for water used, with which to retire bonds. Tentative program, brief details of which are given, has been developed, involving construction of 6 dams.—*R. E. Thompson.*

Pine View Dam Will Not Harm Ogden Artesian Water Supply. Eng. News-Rec., **115**: 596, October 31, 1936. Investigation of artesian wells in Ogden Valley has been carried out by United States Geological Survey to determine effect of Pine View Dam on water supply of Ogden, Utah. When dam being constructed by Bureau of Reclamation at short distance below head of valley for irrigation purposes is completed, wells at Artesian Park will be from 30 to 40 feet under water. Provision is made to pipe flow from wells through reservoir and dam to city. Survey indicated that filling of reservoir would

exert pressure on artesian bed, thereby increasing pressure and discharge from wells. Because of high compression of soil, it is not considered probable that reservoir water will seep into artesian bed. Unless there should be heavy pumping in future from wells in recharge area, artesian supply will be adequate for at least present rate of consumption.—*R. E. Thompson.*

Underground Water Storage in California's South Coastal Basin. Eng. News-Rec., 115: 733–8, November 28, 1935. Interesting discussion of exhaustive investigations on underground basins of South Coastal Basin (known generally as "Southern California"). Major basins are the 3 interior valleys and the coastal plain, but there are 37 more or less distinctly delimited basins, or sub-basins. For 58-year period of rainfall record, 4200 square miles embraced in South Coastal Basin give safe yield of about 700,000 acre-feet, or about 170 acre-feet per square mile. About 5 acre-feet of underground storage space is required for each acre-foot of annual yield. Population of Basin at last census was 2,500,000, of which 2,200,000 centered in Los Angeles and satellite cities occupying western 40 percent of area. Total supplies to be available to basin when work under way is completed (Colorado Aqueduct, etc.) will be about 1,900,000 acre-feet. Large part of investigation was devoted to determining capacity of basins and supply to and demand on each. Evaluation of capacity was based on determinations of specific yield, i.e., drainable voids in valley fill between any 2 levels.—*R. E. Thompson.*

Acid and Permeability Tests of Cement Pipe. Eng. News-Rec., 115: 875, December 26, 1935. General conclusions reached by joint committee of Institute of Civil Engineers of Denmark and Danish Cement Products Association from tests made at Building Research Laboratory of Danish Royal Technical College, as reported by E. S. SUENSON in bulletin (B 15) of Ingeniorvidenskabelige Skrifter. Using acid water containing from 35 to 535 p.p.m. free carbon dioxide, up to 135 p.p.m. aggressive carbon dioxide, and about 240 p.p.m. half-bound carbon dioxide, pipe of 1:2 portland cement mortar with 8 to 10 percent water content suffered only erosion of interior surface to extent of 0.7 mm. in 33 years under head of 6.6 feet. Water curing insured tight molding, even in pipes made from driest mixes; but water curing is unnecessary when sufficient mixing water is used. Pipe of 1:1.5 cement mortar was no better than pipe of 1:2 mix. Thin coatings of tar, applied by dipping or cold painting, are rapidly destroyed by acid. Pipe of 1:5 mix dipped in hot viscous (heavy) tar or asphalt was, however, equal in acid resistance to uncoated pipe of 1:2 mix. Since heavy coatings have tendency to blister in time, it seems preferable and more economical to use richer mix and dispense with coatings. Exposure of portland cement mortar bars to lactic, carbonic, and hydrochloric acids in concentrations of 0.1 to 0.3 normal showed that it was immaterial whether first week's curing took place in water, or in very damp air; and that mortar may lose 30 percent of its strength when thoroughly permeated with water. Dipping in water glass improved watertightness of mortars without, however, increasing acid resistance. Addition of soap to mixing water improves watertightness and increases acid resistance slightly, but reduces strength as much as 33 percent. Water-

tightness of pipe will apparently decrease at beginning of test owing to expulsion of air from pores of pipe shell.—*R. E. Thompson.*

Bills Brook Dam, Hartford. Eng. News-Rec., 115: 698, November 14, 1935. Contract was awarded in June by Metropolitan District of Hartford County for upper portion of project, supplementing stream control works and lower part of dam just completed under previous contract. Unit prices given.—*R. E. Thompson.*

Colorado River Desilting at Imperial Dam. Eng. News-Rec., 115: 538-41, October 17, 1935. Details given of silt problem at Imperial diversion dam, built by Bureau of Reclamation to divert 15,000 second-feet of Colorado River water into All-American Canal, and of plant built for removing large part of load of silt, estimated at 60,000 tons per day, which would otherwise be carried into canal and entail yearly cost for removal of possibly more than $1,000,000. Desilting plant was designed on basis of maximum load of 90,000 tons of silt coarser than 300-mesh, which, it is estimated, will be reduced to 20,000 tons. Maximum velocity in basins is 0.24 feet per second; detention period, 14 minutes; and depth, 12.5 feet, sloping to 14 feet at central draw-off wells of scraper mechanisms. There are 6 basins, 269 x 769 feet in area, each with rated capacity of 2000 second-feet, and provision has been made for 2 additional basins. Deposited silt will be removed by 72 rotary scrapers, each 125 feet in diameter. Extensive model tests were made.—*R. E. Thompson.*

Dissolved Solids Content of Colorado River Water Analyzed. Eng. News-Rec., 115: 567, October 24, 1936. Significant analytical data not yet published have been tabulated and made available for public inspection in office of United States Geological Survey. Weighed annual average content of dissolved mineral matter during period 1926–1934 varied from 491 to 960 p.p.m. Weighted average for period was 593 p.p.m. and it is expected that water from behind Boulder Dam will not vary as much as 100 p.p.m. from that figure.—*R. E. Thompson.*

Man-Made Earthquakes. FRANKLIN P. ULRICH. Eng. News-Rec., 115: 680–2, November 14, 1935. In 1931, United States Coast and Geodetic Survey undertook program of strong-motion seismological investigations in California. Machine designed by L. S. JACOBSEN and JOHN A. BLUME for setting up vibrations of various amplitudes and periods is described and results obtained to date outlined. Observations have been made so far on 2 dams, and on several buildings, bridges, and ground areas.—*R. E. Thompson.*

Montreal to Build New Intakes for St. Lawrence River Water. Eng. News-Rec., 115: 849–50, December 19, 1935. Present intake consists of 2 submerged lines, 6 feet in diameter and 1200 feet long, extending well out into main stream (St. Lawrence River), at Ville LaSalle, about 8 miles upstream from Montreal Harbor. These pipes, which have combined capacity of 80 m.g.d., as compared with ultimate pumping station capacity of 300 m.g.d., discharge

through gatehouse at head of open aqueduct extending to St. Joseph Street pumping and filtration plant located near boundaries of Montreal and Verdun. In addition, there are 2 subsidiary pipes, 600 feet long, which draw shore water consisting largely of Ottawa River water (latter river flows into St. Lawrence several miles above intake), which is characterized by heavy silt content as distinct from clear water of St. Lawrence. Plans have been prepared and bids received on new intake to consist of six 7-foot reinforced concrete pipes extending 2200 feet into river, discharging into aqueduct short distance below upper end of channel. At outer end of each pipe there is to be intake manifold of 6 openings built at right angles to line of pipes and lying in direction of flow of river. These right-angle branches containing the manifold will be spaced at 72-foot centers. Contract has not been let owing to limited funds available.—*R. E. Thompson.*

Fort Peck Dredges Designed for High Capacity on Long Pipe Lines. Eng. News-Rec., 115: 810–3, December 12, 1935. Details given of design of dredging plant for 100,000,000-cubic yard hydraulically-placed earthfill for Fort Peck Dam. Requirements were for plant for transporting materials distances of up to 17,000 feet, to elevations as high as 240 feet, on schedule of 3,000,000 cubic yards per month. Pipe lines are 28 inches in diameter, much larger than is usual. Each of 4 dredging units consists of dredge with two 28-inch pumps set in tandem, each driven by 2500-h.p. electric motor, one floating booster plant with two 28-inch pumps, also set in tandem, and 1 land booster, mounted on railroad car trucks, with one 28-inch pump.—*R. E. Thompson.*

Aluminum Foil Substituted for Lead in Pipe Jointing. Eng. News-Rec., 115: 877, December 26, 1935. M. MENGERINGHAUSEN reported in Gesundheits-Ingenieur, September 14, 1935, on investigation carried out by domestic engineering section of Verein Deutscher Ingenieure of substitutes for lead, owing to German Government's action in forbidding use of lead in jointing cast iron drain pipes in connection with policy of reducing use of imported materials. Aluminum pipe joint now recommended by section is made of aluminum foil 0.002 to 0.004 inch thick, which is creased, crumpled, and calked into space between bell and spigot. Calking is as simple as with lead and to certain extent more convenient, owing to weight being only one-quarter that of lead. Instead of 20 mm. usual with lead, depth can be reduced to 10 mm., due principally to tensile strength being from 3 to 10 times higher. With good yarn packing, aluminum joints of this depth have been known to withstand pressures of about 150 pounds per square inch without leakage. Cost, for 2-inch to 6-inch pipe, is practically same as for lead, or possibly 10 percent less. Molten aluminum cannot be used, owing to high melting point and high heat of fusion.—*R. E. Thompson.*

A New Pipe Jointing Compound That Ensures Immediate Tightness of Joints. Eng. Contract Record, 50: 18, January 8, 1936. Through Mellon Institute of Industrial Research, Pittsburgh, new product, termed "Tegul Mineralead," has been developed. Four hundred feet of 8-inch pipe recently jointed with this material showed absolutely no initial leakage under pressure

of 115 pounds per square inch. On 2200 feet of 6-inch pipe, only 4 joints dripped, in contrast to usual leakage from at least half joints had ordinary sulfur cements been used. Other installations gave similar results.—*R. E. Thompson.*

Details of Water Filtration Plants in Canada. Eng. Contract Record, **50**: 19–20, January 8, 1936. Complete list of plants is given compiled by A. E. BERRY for Waterworks Information Exchange, Canadian Section, American Water Works Association. There are 125 plants serving population of approximately 2,900,000.—*R. E. Thompson.*

Boulder Dam: Past Construction and Work Yet To Be Done. WALKER R. YOUNG. Eng. News-Rec., **115**: 878–83, December 26, 1935. Major facts relating to construction and work uncompleted are reviewed and discussed. Water was first stored back of dam on February 1, 1935, and sufficient water was in reservoir in July to supply all downstream irrigation demands for 12-month period. Spring run-off, reaching maximum discharge above 100,000 second-feet, was reduced this season by gates of dam to less than 1500 second-feet and discharge could have been entirely stopped if necessary. There is noticeable reduction in silt carried by river below dam. Lake is clear for 75 miles upstream and river for more than 10 miles downstream. Work will be concluded about 2 years in advance of date originally specified.—*R. E. Thompson.*

The Old World's Highest Dam Constructed in France. Eng. News-Rec., **115**: 876–7, December 26, 1935. From deepest foundation to crest, Chambon Dam, on Romanche River in southeastern France, is highest dam outside of United States, being 450 feet high at maximum cross-section. Details, from July and August 1935 issue of Travaux, are given. Structure, which is gravity section of cyclopean concrete, was built for hydro-electric development.—*R. E. Thompson.*

Ozone for the Purification of Water. THEODORE RICH. Eng. Contract Record, **49**: 1054, December 11, 1935. Ozone, discovered and named by SCHÖNBEIN in 1843, can be detected by its odor in dilution of 1:2,000,000 in air. As result of studies of P. OTTO, commenced in 1898, installation for water purification was made at Nice in 1905. At present time there are about 75 installations in use in France, in addition to plants in Belgium, the Congo, Italy, and Roumania. In May, 1932, French Council of Public Health, scientific commission for study and control of water supply of Paris, decided to abandon use of chlorine and extend use of ozone for sterilizing water from Seine and Marne Rivers. Ozone plant at Marne pumping station had been in service for number of years prior to that date. (From Engineering.)—*R. E. Thompson.*

New Organization Established to Correlate Hydraulic Research. HERBERT N. EATON. Eng. News-Rec., **115**: 855–6, December 19, 1935. Brief details given of the organization, objectives, qualifications for membership, etc.,

of the International Association for Research on Hydraulic Structures, which was founded at Brussels in September 1935. Further information will be given in National Bureau of Standards Hydraulic Laboratory Bulletin, Series A, No. IV–1, to be issued in January, 1936.—*R. E. Thompson.*

Rocker and Suspender Supports for Large Water Pipes at Tacoma. Eng. News-Rec., **115**: 816, December 12, 1935. Brief details given of methods used in Tacoma, Washington, for providing for expansion and contraction in steel pipes subjected to considerable range of temperature at exposed locations, such as stream crossings. Methods are: (1) suspender bars that sling pipe beneath overhead bridge, and (2) rocker arms that transmit load to concrete piers, between which pipe is self-supporting.—*R. E. Thompson.*

Wellpoint Installation Solves Water Problem in Excavation for Toronto Water Works Pumping Station. Eng. Contract Record, **49**: 899–902, October 16, 1935. Moretrench system of 102 well points connected to header leading to pump discharging into lake lowered ground water level sufficiently to enable excavation and placing of foundation concrete to be carried out in the dry. Samples of water discharged showed it to be free of sediment. Pumping station, consisting of 4 parts, intake and screen section, low lift pump section, high lift pump section, and administration and control section, is part of Victoria Park plant now nearing completion.—*R. E. Thompson.*

Electrical Plumb-Bob for Recording Water Depths. Eng. Contract Record, **49**: 1053–4, December 11, 1935. Brief illustrated description of Evershed automatic plumb-bob level indicator for boreholes (Marchment-Needham patents) installed at Pann Mill pumping station, England. Device consists of electrical element, which automatically stops at water level, suspended by cable wound on motor-driven drum. Length of cable paid out is indicated and recorded, with reference to standard datum, on switchboard panel. —*R. E. Thompson.*

Detachable and Forged Drill Bits Compared by TVA. Eng. News-Rec., **115**: 884–7, December 26, 1935. Tests covering complete quarry operations for 5 months indicate that for large quarry practice, under conditions obtaining at Norris Dam, detachable bits are cheaper than forged, largely because their harder and sharper cutting edges result in faster drilling, and because of saving in steel-handling costs. Data extracted from report by A. J. ACKERMAN are given.—*R. E. Thompson.*

Experience in Three Mines Favors Detachable Drill Bits. Eng. News-Rec., **115**: 887–8, December 26, 1935. Three mines in widely separated locations have reported results of thorough trials with removable bits, by use of which all 3 show substantial savings. Data from reports given.—*R. E. Thompson.*

Constricted Channel Causes High Flood after Record Rainfall at Houston. Eng. News-Rec., **115**: 900, December 26, 1935. Maximum flood of roughly 55,000 second-feet poured down Buffalo Bayou through Houston, Texas,

December 8 and 9, reaching stages 7 feet higher than in 1929, which was considered maximum up to that time. Much damage was done and means of preventing recurrence are being studied. Rainfall ranged from 6 inches in city to 20.8 inches near center of the 406-square mile watershed, within 42-hour period. Average runoff intensity at peak was roughly 135 second-feet per square mile.—*R. E. Thompson.*

Water Supply System for the Town of Hedley, B. C. W. R. BONNYCASTLE. Eng. Contract Record, 50: 17–8, January 8, 1936. New supply system of Hedley consists of concrete dam, 85 feet long, on Twenty Mile Creek and 3.5-mile wood-stave pipe line to town and 2 mills. For 10,800 feet, line is 10 inches in diameter, branching then into 6- and 8-inch lines. Maximum head is 600 feet. Boiler was provided in small house over intake chamber to prevent freezing in chamber and pipe line during extremely cold weather (30° or more below zero).—*R. E. Thompson.*

Long Wood Stave Pipe Line Supplies Water to the Town of La Tuque. Eng. Contract Record, 50: 15–7, January 8, 1936. Brief illustrated description of recently completed 44-inch continuous stave wood pipe line for conveying water from Lake Wayagamac River 7.5 miles to La Tuque, Quebec, town of 7,200 population. Cost of project was $300,000. Staves are of well-seasoned, No. 3 Douglas fir with twin-tongue interlocking butt joints which remain leak- and frost-proof during life of pipe. Finished thickness is 1¾ inches. After milling, staves were creosoted by empty cell vacuum process so as to absorb at least 8 pounds creosote per cubic foot of wood. Gravity head on line, which is said to be longest high-pressure line of its size in Canada, is 250 feet. Construction was accomplished in record time of 2.5 months' working time.—*R. E. Thompson.*

Suggestions for Preventing Algal Growths in Water Supply Reservoirs. Eng. Contract Record, 50: 21, January 8, 1936. In connection with construction of 3 new reservoirs for London, England, following recommendations for prevention of excessive algal growths were submitted to engineering department of Metropolitan Water Board: (1) Area per unit volume should be as small as possible, within limits imposed by engineering practice. (2) Baffle or dividing walls should be omitted and dead areas avoided. (3) Where necessary, alternative inlets should be provided to promote circulation. (4) Orientation should be such that long axes are up and down wind, with view to promoting wave action over entire area, which is prejudicial to algal development. (5) Bottoms should be smooth, with sufficient thickness of gravel, and sides should have as steep a pitch as possible, and should be constructed of smooth concrete slabs without interstices, thereby providing surface which may be easily cleansed, and eliminating cavities in which algae may lodge and multiply. (6) Provision should be made for drawing water at different levels. (7) Facilities should be made for bypassing water when necessary.—*R. E. Thompson.*

Aberdeen Abandons Wells for Treated Surface Water. W. W. MATTHEWS. Eng. News-Rec., 115: 361–5, September 12, 1935. Illustrated description of new supply of Aberdeen, S. D., which replaces receding hard-water well supply which had been used for 50 years. Soap savings are estimated at 125,000; more than fixed charges on entire investment. It is believed that growth of city has been retarded during last 2 decades by hardness and inadequateness of water supply. Most suitable reservoir site was found on Willow Creek, 20 miles northwest of Aberdeen, where it discharges into Elm River; water can be released into latter as needed, using river channel as conduit, obviating necessity of long pipe line. Project includes 2 diversion dams on Elm River, 7.5 miles from city, to impound 230 million gallons; 4-m.g.d. softening and filter plant; 7.5 miles of 20-inch force main from plant to city; and 500,000-gallon elevated tank to supplement low service storage of 1,250,000 gallons in city. Willow Creek Dam, which forms 1400-million gallon reservoir, is earth structure, 1000 feet in length. The 2 diversion dams of Elm River are of concrete, one located 1.5 miles downstream from plant, the other, 3 miles upstream. Both dams, 7 and 8 feet high, respectively, above footings, are of ogee type with crests of 100 feet, and are surmounted with 4-foot flashboards. Respective storage capacities to top of flashboards are 60 and 170 million gallons. Purification plant consists of rapid mixing basins, flocculators, settling basins, carbonation basin, 4 rapid sand filters, and chlorine and ammonia machines. Lime is added in first mixing basin and, after 30 minutes retention in flocculator and 2 hours in settling basin, water is recarbonated and passed to second mixing basin, where alum and activated carbon are applied, and then through second flocculator and settling basin. Chemical dosages employed at present time are: lime, 12 grains per gallon, alum 0.5 grain, activated carbon 2 p.p.m., chlorine 5 pounds per million gallons. Soda ash can be applied when desired; but at present non-carbonate hardness is negligible. The 20-inch cast iron pipe line was laid in 18-foot lengths with joints of Leadite and braided hemp. Leakage 6 months after placing in service was only 404 gallons per 24 hours at 55 pounds pressure, or less than 3 gallons per inch-mile per day. Cost of project, which was built under PWA regulations, was $570,000, exclusive of real estate, engineering, and legal expenses.—*R. E. Thompson.*

The Function of Chlorine and Ammonia in Water Treatment. ATMORE GRIFFIN. Eng. Contract Record, 49: 785–7, 1935. General discussion. Importance of thorough mixing is demonstrated by the fact that when equal amounts of chlorine are added to 2 samples of same water containing ammonia and one is mixed gently, the other vigorously, latter will have higher residual chlorine content.—*R. E. Thompson (Courtesy Chem. Abst.).*

Groundwater Relieves Drought Emergency. G. H. TAYLOR and R. M. LEGGETTE. Eng. News-Rec., 115: 359–61, September 12, 1935. All unappropriated surface water having been exhausted and low precipitation having interfered with water secured from irrigators in Jordan Valley in exchange for Utah Lake water, for which city had established rights, but which is unsuitable for domestic use, ground water supply for Salt Lake City was

developed just in time to prevent shortage. In cooperation with Geological Survey, investigation of ground waters of Jordan Valley had been begun in 1931. When project recommended as result of this study was completed, it was found that of 17 wells drilled, 14 were producing yield of 29.7 m.g.d. Total cost was about $250,000, or less than $8,500 per m.g.d. Cost of completed wells alone, ready for pump installation and including non-producers, averaged about $5,030 per m.g.d. Wells will probably be used only when surface supplies are inadequate or during heavy demand periods. Observation wells have been established to determine effect of new ground water developments on levels and pressures.—*R. E. Thompson.*

Automatic Control of Water Works Pumping Plants. Eng. Contract Record, 49: 727–8, August 21, 1935. Brief illustrated description of control equipment installed by South Staffordshire Waterworks Company, England, to enable Kinver pumping station, which is normally operated automatically by water level in reservoir, to be controlled from Prestwood pumping station, 5 miles distant.—*R. E. Thompson.*

Effect of Blowing Down on Ties. C. D. Turley, G. M. Cornell, E. M. Grime and R. N. Foster. Railway Engineering and Maintenance, 32: 9, 550–551, 1936. Chemicals in boiler water blown out on roadbed from locomotives do not damage either ties, or track structure, where proper track drainage is provided.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Starting Pumps on Long Lines. E. M. Grime. Railway Engineering and Maintenance, 32: 9, 553, 1936. When plunger type, or positive acting, pumps are operated on long pipe lines, by-pass lines should be used when starting up, so as to cause a gradually increasing flow until normal working pressure and velocity have been attained, in order to prevent damage to pipe joints. Centrifugal pumps are recommended for such service.—*R. C. Bardwell.*

Indicators. I. M. Kolthoff. Ind. Eng. Chem., Anal. Ed., 8: 4, 237–9, 1936. Brief survey of acid-base, oxidation-reduction, adsorption, and specific indicators; with suggestions for studies leading to desirable developments.—*Selma Gottlieb.*

Determination of Iron in Humates. Norman Ashwell Clark and Dale H. Sieling. Ind. Eng. Chem., Anal. Ed., 8: 4, 256–7, 1936. "Ferron," 7-iodo-8-hydroxyquinoline-5-sulfonic acid, suggested by Yoe, gives green color with ferric iron, permanent in pH range 2.7 to 3.2. Few substances interfere. Permanent standards can be made for test. Ferrous iron does not react with reagent.—*Selma Gottlieb.*

Measuring the Thickness of Thin, Flowing Liquid Films. Herbert H. Beck and K. G. Weckel. Ind. Eng. Chem., Anal. Ed., 8: 4, 258–9, 1936. By determining change in point of reflection of projected light beam, thickness of thin, flowing liquid film can be measured. Method is suitable for study of milk being irradiated, to detect variations in film thickness, such as those

caused by changes in velocity, within successive short intervals.—*Selma Gottlieb.*

Determining the Resistance of Portland Cement to Sulfate Waters. R. W. STENZEL. Ind. Eng. Chem., Anal. Ed., 8: 4, 263–6, 1936. An accelerated test. Slabs prepared by standard method are immersed in 10 percent sodium sulfate solution after seven days aging, and warping determined by difference in spherometer readings after seven and twenty-one days immersion. This work was done in connection with construction of Colorado River Aqueduct by Metropolitan Water District of Southern California, where specifications for cement were designed to give maximum resistance against sulfate waters. —*Selma Gottlieb.*

Effect of Impurities on Corrosion Resistance of Solder. CLIFFORD L. BARBER. Ind. Eng. Chem., 28: 5, 530–3, 1936. Antimony, copper, and zinc decrease corrosion resistance of tin alloys, and should be excluded from solder.—*Selma Gottlieb.*

Permeability of Paint Films to Moisture. JUNIUS D. EDWARDS and ROBERT I. WRAY. Ind. Eng. Chem., 28: 5, 549–53, 1936. Below about 80 percent humidity at 80°F., moisture permeability is closely proportional to water vapor concentration at moist surface; but above this humidity, penetration of film increases more rapidly. Between 60° and 90°F., temperature coefficient of moisture impedance is low, moisture content of air being held constant. On aging, or exposure to air, moisture impedance shows little change during initial period, but eventually increases sharply. Soon after, film shows slow, or rapid, decrease in moisture impedance, which reaches very low value at failure of paint film.—*Selma Gottlieb.*

A Little of the Perspective of Acid-Base and Oxidation-Reduction Equilibria. W. MANSFIELD CLARK. Ind. Eng. Chem., 28: 5, 620–4. 1936. Nichols Medal address. A review—*Selma Gottlieb.*

Sulfite Waste Liquor. H. K. BENSON and A. M. PARTANSKY. Ind. Eng. Chem., 28: 6, 738–40, 1936. Sugars in sulfite waste liquors can be destroyed by anaërobic fermentation, B. O. D. being reduced about 80 per cent. Residue contains chiefly lignin. When sufficiently diluted, all organic matter of sulfite waste liquor is oxidized biochemically, providing solution of sulfite waste liquor problem.—*Selma Gottlieb.*

Activated Alumina for Removing Fluorides from Drinking Water. G. J. FINK and F. K. LINDSAY. Ind. Eng. Chem., 28: 8, 947–8, 1936. Using a specially prepared activated alumina, 250 gallons of water containing 5 p.p.m. of fluoride can be passed through a 6-inch layer containing about 9¾ pounds of the material, at rate of 0.4 gallon per minute before fluoride content of effluent reaches 1 p.p.m. Chemical regeneration is possible, but not feasible for household units developed; alumina in these should be replaced after exhaustion. Eight percent sodium hydroxide, or sodium aluminate con-

taining 8 percent total sodium hydroxide, gives complete regeneration. Efficiency and capacity of material depend on pH of water treated, lower pH in potable range being best. Treatment with lime, or with metallic magnesium, is much less effective in fluoride removal than treatment with alumina.—*Selma Gottlieb.*

Tetrahydroxyquinone. Anon. Ind. Eng. Chem., News Ed., **14:** 9, 178, 1936. W. H. & L. D. Betz Laboratories, 235 West Wyoming Ave., Philadelphia, Pa., can supply tetrahydroxyquinone indicator for direct titration of sulfate. Method is suggested by American Society for Testing Materials as control for determination of sulfate in boiler waters. Two-tenths gram of indicator is required for each test.—*Selma Gottlieb.*

Precautions in Handling and Using Liquid Chlorine. C. H. S. TUPHOLME. Ind. Ang. Chem., News Ed., **14:** 11, 217, 1936. From discussion by F. HOLT, before Chemical Engineering Group in London. First requisites for safety are container of adequate strength, prevention of overfilling, and detailed record of history of container. In withdrawing chlorine, precautions should be taken to avoid drawing liquid from absorption vessel into exhausted container. All equipment used in handling, storing, and transporting liquid chlorine should be adequately serviced and tested periodically. Respirators should be available in case of chlorine leaks, and personnel should be trained in their use.—*Selma Gottlieb.*

Daniel Dana Jackson. ARTHUR W. HIXSON. Ind. Eng. Chem., News Ed., **14:** 13, 266–7, 1936. Biographical sketch and appreciated of the noted sanitarian, chemical engineer, and teacher. JACKSON was first to use copper sulfate as algicide in water supply, installed chlorine treatment for water supplies of New York and other large cities, invented JACKSON turbidimeter, campaigned vigorously to arouse country to importance of various sanitary problems, initiated numerous improvements in water and sewage treatment, and aided in commercial development of zeolite process in America.—*Selma Gottlieb.*

Products Recovered from Sea Water. Anon. Ind. Eng. Chem., News Ed., **14:** 15, 304, 1936. In 2½ years of operation, bromine plant of Ethyl-Dow Chemical Co., near Wilmington, N. C., has recovered over 10,000 tons of bromine from 154,293,000 tons of sea water pumped. Potential values of certain other constituents of sea water are calculated.—*Selma Gottlieb.*

NEW BOOKS

Vom Wasser; Ein Jahrbuch für Wasserchemie und Wasserreinigungstechnik, X Band: 1935. 330 pp. Verlag Chemie, G. M. B. H., Berlin. W. 35. **Purification and Utilisation of Waste Waters.** H. STOOF. 7–12. Outlines treatment of sewage and trade effluents by septic tanks, irrigation, trickling filters, activated sludge, electrical methods, and chlorination; also utilisation for agriculture and recovery of fats. **Separation and Utilisation of Residues from Municipal Sewage.** F. MIEDER and K. VIEHL. 13–32. Screen-

ings make good fertiliser; digested sludge is more suitable and dries more easily than settled sludge. Air-dried sludge has high water content; complete dewatering by heat is impracticable and chemical treatment is costly. Wet sludge when mixed with peat by "Biohum" process yields good and cheap fertiliser. Leipzig system of clean sand recovery from sand traps is described and illustrated. **Fishery Interests.** R. CZENSNY. 33–36. Outlines value of lakes as fisheries. Discharge of pollution therein must be accompanied with efficient mixing with lake water and in deep lakes formation of layer of heavy waste must be avoided. Treatment of phenolic and tarry effluents is discussed. **Haff Disease and Resin Acids of Pine Wood.** EMDE. 37–44. Illness caused by eating poisoned fish from Frisches Haff at first attributed to arsenic, later to resin acids of pine wood discharged from factories. This factor also disproved, poison may be due to secondary biochemical reactions during warm weather. There have been 13 deaths in ten years. **Treatment of Sulphite Effluents in Königsberg.** F. HURDELBRINK. 45–59. Describes purification of cellulose-sulphite effluents by filtration through ground filters whereby pollution of the Haff by high sulphur content is much reduced. **The Permanganate Figure in the Evaluation of Cellulose Factory Effluents.** H. HAUPT. 60–77. Determination of permanganate figure alone is insufficient; for organic substances present in sulphite liquors have very high permanganate value. In laboratory, biological decomposition of domestic sewage is 60 percent in a month; of sulphite effluent, only 20 percent. Sulphite effluents show greater resistance to decomposition by micro-organisms than does domestic sewage. **Production of Unobjectionable Water from Polluted River Water.** A. SPLITTGERBER and W. DEMMERING. 78–98. Owing to increased river pollution, textile works have installed general water purification plant. Water is flocculated with alum and lime, allowed to settle, and then filtered; manganese, iron and hardness being thereby suitably reduced, and color removed. **Removal of Turbidity and Color by Precipitation.** E. LINK and W. GANDENBERGER. 99–112. Experiments on treatment of water with aluminum sulfate and ferric chloride, with additions of clay, fullers' earth, and powdered carbon, are described and illustrated by curves. With river water ferric chloride gave better floc and settling than aluminum sulfate; but with lake water, difference was small. Ferric chloride is expensive and corrosive and penetrates filters; it was therefore discarded. Clear water necessitated large doses of aluminum sulfate; but addition of fine clay halved dose for lake water, and fullers' earth gave similar results; with both, however, earthy taste ensues when much is used. Äeration at inlet of settling tank hastened settling, increased filter runs, and removed odors. **Chemical Purification of Sewage in America.** IMHOFF. 113–126. Chemical treatment of sewage in America dates from 1889; at present, some 50 plants are using chemical coagulants. With chemical treatment, degree of purification is variable at will; extreme of purification need only be given when necessary, at certain seasons. Continuous sludge removal settling tanks and suction filters for sludge dewatering are highly developed in America and are suitable for chemical treatment. Plants at Coney Island, Wards Island, Dearborn, Shades Valley, etc. are mentioned and more extended use of chemical coagulation in Germany is

advocated. **Chemical Precipitation.** H. BACH. 127–128. Aim of sewage purification is elimination of foreign matter. Addition of chemicals increases sludge, adds soluble matter to effluent, and fails to remove dissolved albuminoids. Fine suspended matter can be satisfactorily removed by mechanical filtration. In the Laughlin process a magnetite filter is used. Chemical treatment of sewage is not a substitute for biological treatment. **Prevention of Corrosion Damage by Industrial Effluents.** H. STOOF. 129–141. Deals with corrosive action of industrial effluents, which may contain acids, bases, salts, gases, and organic corrosive agents, upon iron, lead, copper, aluminium, concrete, asbestos-cement, and ebonite. Bibliography of last ten years, comprising 77 references, is given. **Corrosion of Metallic Materials in Waterworks.** G. WIEGAND. 142–154. Describes experiences of Berlin Municipal Waterworks with waters containing carbon dioxide, oxygen, and hydrogen sulphide; first two are mainly responsible for corrosion of metals used in filter fittings, while last is chief agent in corrosion caused by ground waters. Corrosion of copper by hydrogen sulphide may be prevented by bitumen paint; aluminum, which is resistant to hydrogen sulphide, is preferable; further experiments with chrome steel and chrome molybdenum steel arere quired. In under-drainage system of Bollman filters, which is described, phosphor bronze tubes are advocated rather than copper or brass. Corrosion of manganese-eliminating filter is also dealt with, and also corrosion by stray electric currents; deposits produced by corrosion reduce capacity of pipes and may affect accuracy of meters. Bitumen is preferable to asphalt for pipe protection because it is less brittle. **Preparation of Drinking Water, with View to Conserve Materials and Indigeneous Products.** L. W. HAASE. 155–172. Serious losses due to disease and corrosion result annually from non-treatment, or unsuitable treatment, of water supplies. National wealth can be conserved and new indigenous raw materials employed by suitable treatment of waters. **Structure of Cast Iron in Relation to the Corrosion Problem.** E. PIWOWARSKY. 173–185. Discusses properties of cast iron; crystalline structure; graphitic content and form; influence of silicon, phosphorus, manganese, and sulphur; density; and protective coatings. Bibliography of 44 references is given. **Corrosion and Formation of Protective Layers in Cold Water Supply Systems of Cast Iron.** L. W. HAASE. 186–196. Natural protective layer of calcium carbonate and rust is formed under favorable conditions of alkalinity, oxygen content, and depolarisation velocity. Oxidation is influenced by hydrogen ion concentration and by hardness salts and chlorides present. Plant scale experiments show that it is practically impossible to treat water so that it is suitable for all pipe materials. **Corrosion of Tinned Copper Screen on a Well Filter by Water Containing Hydrogen Sulphide.** G. NACHTIGALL and H. SCHRÖDER. 197–200. Photographs and analyses are given of screen corroded by hydrogen sulphide after 4 years use. Analytical figures for water are given with hydrogen sulphide "a trace." **Investigations on the Treatment of Water by the Magno Process.** E. NAUMANN. 201–203. Water is deacidified by percolation through filter containing "magno-mass," which is partially calcined and granulated dolomite, containing calcium and magnesium carbonates and magnesium oxide. Experimental results for four waters are given, using filtra-

tion rates of from 3 to 20 meters per hour. Process is suitable for all soft waters and is unaffected by carbon dioxide content, iron, manganese, and organic matter; it removes acidity, iron, and manganese. **The Concentration of "Heavy Water" in Boilers.** R. STUMPER. 207–208. Investigation of water in boiler after operation for 5146 hours, producing 123,500 tons of steam, showed that there was no increase in concentration of "heavy water," as indicated by specific gravity determinations. **Pre-Heaters and Gas Removal Appliances for Treatment of Boiler Feed Water.** G. AMMER. 209–233. Description, with 19 illustrations, of plants for removal from feed water of gas alone and for gas removal combined with softening; also of methods for preventing access of air to de-gassed feed water. Bibliography is appended. **Water-Softening with Barium Salts.** E. SEYB. 233–264. Softening experiments were conducted with barium hydroxide and with barium carbonate at 30°C. and 90°C., with and without addition of carbon dioxide, and followed, in some experiments, by addition of lime and zeolite treatment. Water used contained 16 degrees (German) of calcium sulphate hardness and approximately the same (13 degrees, German) of carbonate and magnesium hardness. Using barium hydroxide at 38°C., content of salts was reduced by from 33 to 44 per cent; residual hardness was between 4 and 5 degrees (German), so that additional softening with phosphate or with zeolite was necessary. Owing to high price of barium hydroxide this process was considered impracticable. Using barium carbonate at 38°C., in presence of sufficient carbon dioxide to form bicarbonate, reaction with calcium sulphate is practically quantitative, excess of barium carbonate being unnecessary. Subsequent softening with lime precipitated carbonate hardness, residual 2 or 3 degrees being removed by phosphate or zeolite. New process is proposed in which water, after treatment with barium carbonate, is passed through hydrogen, or acid, zeolite, water and carbon dioxide being formed. Experiments at 90°C. gave similar results to those at 38°C. **Calculation of Amounts of Chemicals Necessary for Water Softening by the Lime-Soda Process Followed by Phosphate Treatment.** L. SURAN. 265–289. A physico-chemical discussion on HUNDESHAGEN'S formulae for calculating amounts of chemicals required for water softening, giving supplementary formulae for lime-soda treatment with and without subsequent phosphate treatment. **Calcium Hydroxide Treatment of Cooling Water for Surface Condensers.** G. AMMER. 290–305. Describes two plants for removal of carbonate hardness from condenser water by lime treatment. This is specially suitable for water with high calcium bicarbonate content and low pH value, particularly if presence of solid matter makes filtration necessary. **New Books, etc.** Nineteen recent additions to the literature, chiefly German, are reviewed at some length.—*W. G. Carey.*

Fifteenth Annual Report of Ohio Conference on Water Purification, Cleveland, October 3–4, 1935. 58 pp. (1936). **Low Lake Levels and the Avon Lake Village Water Supply.** J. C. BRITTON. 12. The 24-inch cast iron intake, about 40 years old, has high point 200–300 feet from shore. Owing to low lake levels, pumps lost suction on 4 days in December, 1934. Lowering of high point in line would have been expensive and could not have been completed in time to relieve situation. By carrying intake line below lake level in

receiving well and maintaining vacuum of 2 inches on suction line to exhaust air, no difficulty was experienced when lake level reached lowest point in January. **Low Lake Levels and the Sandusky Water Supply.** O. F. SCHOEPFLE. 12. Intake, of 42-inch cast iron pipe, terminates in vertical cylindrical concrete shaft about 1800 feet from purification plant in about 8 feet of water. Elevation of ports is 5.42 feet below mean water level of Lake Erie. In January, high wind lowered level of Sandusky Bay to —5.65 and, for period of about 3 hours, plant was without raw water. Supply to city was not interrupted, pure water storage being ample to meet emergency. Gate, equipped with chains and hinges, has been cut in intake line near crib, at elevation of —6.94, which will permit drawing water from point 1.52 feet lower than bottom of crib ports during such emergencies. **Dredging the Barberton Reservoir.** A. D. CLAGGETT. 13. Barberton Reservoir covers area of 200 acres, part of which is shallow and of swampy nature. Minimum depth is being increased to 10 feet by dredging at cost of 14 cents per cubic yard. It is expected to remove about 300,000 cubic yards of muck during next 6 years. Dredged material is being used for fill, preparatory to planting pine trees. Dredge, which is described, was built at cost of 111,500. Work will greatly increase capacity of reservoir and will, it is hoped, materially reduce algae difficulties. **Corrosion Difficulties and the Remedy at Findlay, Ohio.** A. V. FOLTZ. 14. Well supply of Findlay is softened, part by base exchange and part with lime-soda, effluents being mixed to give final hardness of about 85 p.p.m. Corrosion has been reduced (but not entirely eliminated) by adjusting final pH to 8.9 and maintaining carbonate hardness above 30 p.p.m. **Description of Automatic Devices at the Filter Plant at Huron.** A. V. AICHER. 14–5. Filter plant consists of dry-feed machine, coagulation basin, one new 0.6-m.g.d. and two older 0.375-m.g.d. filters, and chlorination equipment. Operation is entirely automatic, except for washing of filters. Equipment described briefly. **Slag as a Filter Medium.** L. W. RADMAN. 15. Slag used in experiments was residue from combustion of pulverized coal under boilers. As molten slag runs into pit, it is cooled by high-pressure stream of water which disintegrates it into fine particles. Analysis showed specific gravity 2.67, effective size 0.62 mm., and uniformity coefficient 2.6. After 6 months' operation of filter containing 26 inches of this slag, cracks, mud balls, and mud accumulations appeared. This condition has been somewhat improved by hosing surface during washing and filter is now giving longer runs than sand filters. It is believed that, with effective size of 0.4 mm. and uniformity coefficient of 1.6, together with higher rate of wash, or auxiliary surface wash, slag would be fair filter medium. **Results Obtained with Low Coagulant Application at Cleveland.** W. C. LAWRENCE. 15–6. During past summer, turbidity averaged 1 to 2 p.p.m. Although experience has shown that minimum dosage of alum required to form floc is 0.6 grain per gallon, dosage was reduced to 0.4, 0.2, and finally, for period of 62 hours, to zero. Treatment was then resumed at 0.4, later increased to 0.8. Results were as follows:—(1) filter run average increased from 45 to 91 hours; maximum from 56 to 229 hours; (2) clarity of filtered water remained unchanged; (3) pH of filtered water increased from 7.4 to 8.1; (4) no increase occurred in *B. coli* content of filtered water; and (5) operating costs were reduced through

saving in coagulant and in wash water. Difficulties encountered were as follows:—(1) bacteria growing at 20° and 37° increased; and (2) organic tastes and odors developed in filtered water. Further experiments are being made to determine whether difficulties can be eliminated. Results so far indicate:—(1) development of tastes and odors can be prevented by filtering to waste for 30 minutes before filter is placed in service, or, if filter has to be out of service, it should be drained and, when again being placed in service, filled and rewashed thoroughly and (2) activated carbon, 0.1 to 0.2 p.p.m., applied to filter, is also effective in preventing tastes and odors. **Problem of the Private Well.** 16. Question was raised regarding extent to which justification exists for condemning well supplies showing positive presumptive *B. coli* tests, when supply has been used for years without apparent harm. It is generally recognized that some people using contaminated drinking water develop immunity. Instance is quoted of typhoid epidemic which originated from well long thought harmless, with ill effect to owner's family. **A Review of Water Purification and Water Softening Literature for the Year 1935.** CLARENCE BAHLMAN. 17–21. Brief review and discussion of more important papers of year. **Licensing of Water Works Employees.** LEWIS V. CARPENTER. 22–7. Discussion of advantages of licensing, based upon summary of opinions of American Water Works Association Committee on Licensing and information obtained by correspondence with operators in various sections of country. Licensing is practised in Michigan, New Jersey, West Virginia, Ohio, and Texas, Ohio operating under Registration Law for Professional Engineers and in Texas licenses (voluntary) being issued by Texas Division of Southwest Section of American Water Works Association. Alabama, California, Kansas, Kentucky, Maryland, and Wisconsin have laws which would probably allow licensing. Conference went on record as favoring licensing of water works employees. **A Comparison of the B. Coli Results at Ohio Filtration Plants in 1934.** THOS. R. LATHROP. 28–30. Tabulations of *B. coli* indices of raw waters, unchlorinated filter effluents, and disinfected plant effluents of 33 plants are given and discussed briefly. Presentation of similar data at previous conferences stimulated operators to improve rating of their plants and employ technique which permits inclusion of results in tabulation. **Mixing Chamber Practice.** PHILIP BURGESS. 31–5. Salient features of devices used for conditioning water for coagulation are discussed and several typical installations are described to illustrate trend in modern design. Experience has indicated that velocity of flow in conditioning units should be not less than 0.3, or more than 1.0, foot per second and detention period not less than 20 and usually between 20 and 40 minutes. In cases where very gentle agitation is required, e.g., soft, highly colored waters, period of detention should be proportionately extended to from 1.0 to 1.5 hours. Flexibility in regard to velocity and period of mixing is important. In discussion, C. P. HOOVER questioned necessity of so-called flash or rapid mix prior to conditioning. **The Cross-Connection Problem.** J. W. ELLMS. 36–9. General discussion of direct and indirect cross-connections. Following presentation of paper, control activities in Toledo, Akron, and Marion were outlined. In latter city, some private consumers have pumped well supplies. When repairs to private system are necessary, city supply is used and, in

some cases, when repairs are completed, well water is pumped back through meters into mains so that water used will not have to be paid for. Remedy in such cases is disconnection. **Comparative Effects of Ultra-Violet Light Intensities on Chlorine and Chloramine in Water.** E. B. BUCHANAN and J. K. DODGE. 40?2. It is well known that residual chlorine disappears more rapidly in bodies of water, e.g., swimming pools, when exposed to direct sunlight. In investigation of this phenomenon, experiments carried out under carefully controlled conditions, using arc lamp as source of rays, showed that residual chlorine in distilled water dropped markedly when exposed to ultra-violet light. Acidity of water increased in proportion to reduction in free chlorine. Chloramine solutions behaved similarly. Effect was most pronounced with wave lengths between 2500 and 3000 Ångstrom units. **Fundamentals of the Microscope and Its Application.** H. S. BOOTH. 42. Lecture, only brief abstract being given. Applications in analytical work were discussed. **Algae and Their Enumeration.** W. C. PURDY. 43–7. General discussion of algal problems, with particular reference to advantages of cubic standard unit for expressing concentration of organisms. Mere enumeration of algae is likened to timber survey in which number only of trees in area was taken into account without reference to type and size. Use of cubic unit permits conversion to parts per million by volume. As one cubic unit (20-micron cube) contains 8000 cubic microns, there are 125,000,000 cubic standard units in 1 cc. Therefore, $\frac{\text{number of cubic standard units per cc.}}{125}$ = p.p.m. by volume. From experiments cited in WHIPPLE'S book, *Asterionella* content of 10 p.p.m., i.e., 10,000 standard units or 1,250 cubic standard units per cc., would probably be very near danger point so far as odor production is concerned. **The Algae Problem at Norwalk.** G. ALBRO HALL. 48–9. Treatment of impounding reservoir with 0.25 to 0.35 p.p.m. copper sulfate at intervals of 3 weeks in cool months and of 2 weeks during summer aids in maintaining water in good condition; but some of more resistant algae develop in abundance. In 1934, when water temperature reached 52°F., *Synedra* appeared in large numbers. As much as 200 gallons of green scum was removed from mixing chambers daily when plant was operating at rate of 0.7 m.g.d. Prechlorination at rate of 3.0 to 3.5 p.p.m., giving residual of 0 to 0.2 in applied water, was beneficial and taste troubles were minimized by applying activated carbon, 4 to 16 pounds per million gallons, to raw water and on top of filters. A few organisms and traces of carbon passed through filters. *Synedra* persisted in clear well with chloramine residual of 0.5 p.p.m. In 1935, *Synedra* again appeared when temperature reached 52°F., and same treatment was employed except that lime dosage (0.5 grain per gallon) for corrosion control was applied to settled, instead of to raw, water and major portion of carbon was also applied at that point. Coagulation was improved, more complete removal of *Synedra* was effected, and carbon did not pass through filters. Chlorine dosage varied from 3.25 to 3.75 p.p.m. Pad of 6 or 8 layers of fine cheese-cloth on laboratory tap, through which 150 gallons of water is passed, provides good index of number of organisms passing through filters. **Discussion of Algae Problems at Barberton.** F. L. ROLLINS. 49. More than one-half drainage area of Barberton Reservoir is

marshy land and, as result, taste and odors due to microörganisms are acute problems. Troubles experienced during past few years are outlined, together with details of treatment employed. In 1932, *Asterionella* gave rise to intense tastes. Treatment with alum, 3.0 grains per gallon, lime, 0.7 grain per gallon, carbon, 60 pounds per million gallons, and chlorine, 3.0 p.p.m. before filtration and 0.7 p.p.m. after, removed taste and odor at plant; but after-taste developed in mains. Preammoniation enabled alum and lime dosages to be reduced and carbon and post-chlorination to be discontinued, while with chlorine dosage of 1.2 p.p.m., residual chlorine in applied water was 0.35 and in filtered water, 0.25 p.p.m., as compared with 0.15 and 0.05, respectively, from dosage of 3.0 p.p.m. prior to adopting pre-ammoniation. In 1933, after-tastes again appeared, notwithstanding increased chemical dosages, *Anabaena* being predominant organism. Lime softening corrected this condition. Treatment with carbon, 10 pounds per million gallons, in addition to chloramine, is now regularly practised. **Odor Troubles in the Water at Defiance.** FRANK S. TAYLOR. 50–1. Experience with most disagreeable fishy odor is described. Raw water was free of odor; but, after treatment, which includes prechlorination, lime softening, alum coagulation, activated carbon addition, recarbonation, filtration, and final chlorination, very intense odor was present. During laboratory experiments, it was observed that odor could be produced by addition of lime to raw water and then eliminated by neutralization with sulfuric acid. Identical odors, ammoniacal at first and changing to strongly herring-brine, were produced by treating methylamine hydrochloride with lime. Trouble is believed to have been due to amines produced during putrefaction of large numbers of fish which had been killed by beet sugar waste, or present in waste itself. Brine used for salting herring and beet sugar waste are known to contain amines. Only remedy appears to be to discontinue use of lime during such periods. **Algae Conditions in Meander Reservoir.** WILLIAM I. VAN ARNUM. 52. Regular examination of water in Meander Reservoir of Mahoning Valley Sanitary District, supplying Youngstown and Niles, has revealed only 2 organisms, *Coelosphaerium* and *Anabaena*, likely to cause trouble. Copper sulfate treatment of reservoirs has been successful in preventing tastes. In discussion, it was stated that activated carbon had proven most effective in controlling algae tastes at Akron. Algal population is so high at times that filter runs are reduced to 1 hour. Prechlorination has materially aided in relieving this condition. As last resort, copper sulfate treatment is employed. At Lima, where supply is impounded in 2 large reservoirs, from which it flows to secondary reservoirs, copper sulfate treatment of latter is controlled by length of filter runs obtained. It is customary to distribute small crystals of copper sulfate over ice on reservoirs in spring; but in 1935 this treatment was omitted. Suddenly, without decrease in filter runs, bad taste was reported. Microscopic examination revealed very few organisms, *Microcystis* being predominant form. Source of trouble seemed to be in one of primary reservoirs and when this was put out of service it only remained to free secondary reservoirs of organisms. Activated carbon was effective in removing taste. **New Permanent Standards for the Determination of Residual Chlorine.** R. D. SCOTT. 53–4. It is well known that permanent standards of ELLMS and HAUSER (Standard

Methods of Water Analysis) for determining free chlorine with *o*-tolidine are accurate only when viewed through depth of liquid in 300-mm. tube, standards appearing relatively weaker when viewed through tube wall. To avoid this limitation, author has developed new standards, which are accurate in hue and intensity over range 0.01–3.0 p.p.m., whether viewed through length or breadth of tube. Solutions required are: **I**, 0.25 gram potassium dichromate and 0.75 gram potassium chromate in 1 liter distilled water; **II**, 0.25 gram potassium dichromate and 0.75 gram potassium chromate in 100 cc. distilled water; and **III**, buffer solution, pH 6.5; 13.616 grams potassium dihydrogen phosphate and 30.2 cc. normal sodium hydroxide made up to 2 liters with distilled water. Required volume of I or II is introduced into 100-cc. Nessler tube and volume adjusted to 100 cc. with III. I is used for preparing standards for range from 0.01 to 0.30 p.p.m. chlorine, volumes required being for 0.01 p.p.m., 0.3 cc.; for 0.02, 0.7; for 0.03, 1.1; for 0.05, 1.9; for 0.07, 2.8; for 0.10, 4.4; for 0.15, 7.4; for 0.20, 10.0; for 0.25, 13.0; for 0.30, 16.0. II is used for range from 0.4 to 3.0 p.p.m.; for 0.4, 2.1; for 0.50, 2.6; for 0.70, 3.6; for 1.00, 5.2; for 1.50, 8.0; for 2.0, 11.2; and for 3.0, 18.0. Above 3.5 to 4.0 p.p.m., chlorine-*o*-tolidine colors become erratic in tint and subject to rapid changes in intensity. To maintain colors constant, pH of standards must be maintained at 6.5 ± 0.2. Standards so prepared have been used in direct sunlight for as long as 6 weeks without fading. **Dirty Filter Sand, Its Effect on Bacterial Growths in Filter Beds at Elevated Water Temperatures, Remedies, etc.** L. A. MARSHALL. 55–8. During 17 years' use, filter sand in Division Ave. plant at Cleveland has accumulated coating of material (removable with hydrochloric acid) averaging 10 percent of sand by weight. Mud accumulations are in evidence and filter beds are subject to cracking. When water temperature is above 60 to 65°F., beds become virtual incubators, causing objectionable odors and producing large numbers of bacteria which appear in filtered water. When filter out of service for period after washing is again placed in commission, immense numbers of bacteria and strong putrefactive odors show in effluent. After 25 minutes, period theoretically required to displace water in filter, odors disappear and bacterial count is about 90 percent less; but even after 1 hour's operation, count is frequently higher than in raw water. Effluent is always run to waste for 25 minutes after starting filter. Pre-ammonia-chlorine treatment, carrying residual chlorine to filters, resulted in enormous bacterial growths and putrefactive and chloro-organic odors. Various means of cleaning sand, e.g., alkali solutions, hypochlorite, hosing, etc., have been only partially successful. Entire volume of sand is now being washed with Robertson washer and while all but 2 percent of accumulated material is removed, performance of filters after cleaning is somewhat disappointing.—*R. E. Thompson.*

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Water Engineer's Handbook and Directory, 1935. London: Water and Water Eng. 8s. 6d. Reviewed in Gas J., **211**: 145, 1935. From Chem. Abst., **29**: 6340, September 20, 1935.—*R. E. Thompson.*

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Qualités de l'eau et moyens de correction. ÉD. IMBEAUX. Paris: Dunod and Cie. 834 pp. F. 265. From Chem. Abst., **29**: 6988, October 20, 1935. —*R. E. Thompson.*

Boiler Feed and Boiler Water Softening. HARRY K. BLANNING and ALBERT D. RICH. 2nd ed. Chicago: Nickerson and Collins Co. 159 pp. $3. From Chem. Abst., **30**: 1915, March 20, 1936.—*R. E. Thompson.*

Boiler Feed-Water Treatment. F. J. MATTHEWS. London: Hutchinson's Scientific and Tech. Publications. 256 pp. 12s. 6d. Reviewed in Chem. Trade J., **98**: 54, 1936. From Chem. Abst., **30**: 1916, March 20, 1936.—*R. E. Thompson.*

A Manual of Practical Chemistry for Public Health Students. ALAN W. STEWART. 3rd ed. London: The Author. 121 pp. 7s. 6d. Reviewed in J. State Med., **43**: 744. From Chem. Abst., **30**: 1916, March 20, 1936.—*R. E. Thompson.*

Alimentation en eau des villes. Évacuation des eaux usées et des résiduaires. Livre II. Procédés d'analyse et de contrôle des eaux d'alimentation et des eaux usées. GUILLERD A. DIÉNERT, P. ÉTRILLARD, and F. WANDENBULCKE. Paris: L. Eyrolles. 235 pp. F. 35. Cf. C. A., **29**: 4499. From Chem. Abst., **30**: 2676, April 20, 1936.—*R. E. Thompson.*

Procedure Handbook of Arc Welding Design and Practice. 3rd edition. Leather; 6 x 9 inches; 595 pp. The Lincoln Electric Co., Cleveland, Ohio. $1.50. Reviewed in Eng. News-Rec., **116**: 638, April 30, 1936.—*R. E. Thompson.*

The Work of the Sanitary Engineer. ARTHUR J. MARTIN. Cloth; 5¼ x 8½ inches; pp. 488. London: MacDonald and Evans. 16s. net. Reviewed in Eng. News-Rec., 116: 638, April 30, 1936.—*R. E. Thompson.*

Droughts of 1930–34. JOHN C. HOYT. Geological Survey, Water Supply Paper 680. Paper; 6 x 9 inches; pp. 105. Superintendent of Documents, Washington, D. C. 20¢. Reviewed in Eng. News-Rec., 116: 744, May 21, 1936.—*R. E. Thompson.*

Air Conditioning is Causing Large Increase in Use of Ground Water. In a preliminary report on the water resources work of State Geological Surveys, under date of March 29, 1935, Mr. O. E. Meinzer, among other things, called attention to the need of continuing studies on ground water. Although the geology remains static, ground water is not generally static, and its movement under various natural and artificial forces makes it a dynamic system for which the rock formations merely afford the containers and conduits. Any adequate study of ground water supplies requires continuing records of natural discharge, artificial withdrawals, ground water levels, pressure heads, chemical character, and perhaps temperature. With the interpretation of such continuing records, it will be possible to determine the ground water trends and to place the water supplies of every State upon a relatively secure basis.

Correspondence between Mr. E. W. Lane and Mr. Meinzer calls attention to new problems that are being created by the rapid development of air conditioning, and the possibility of strengthening the programs of water level and pumpage inventories. Fear is expressed that the cities dependent upon ground water may suddenly find their sources of supply gone or seriously endangered by the rapid spread of air conditioning. Apprehensive lest a severe ground water shortage should come rather suddenly and before the necessary protective legislation can be adopted, Mr. Lane suggests that warning be broadcast in the water works journals and trade papers, to make a start at building up sentiment for the necessary control and to provide enough forewarning that some of the worst effects may be avoided.

Agreeing with the importance of the subject, Mr. Meinzer advises that the nation-wide program of the Ground Water Division of the U. S. Geological Survey contemplates a continuing inventory of the ground-water supply in every municipality in which the public supplies are obtained from wells or there is a large use of ground water for industrial or other purposes. As a nation-wide program, however, hardly more than a beginning has been made. The Ground Water Division has no fund for this work, except as Federal Funds are matched by State or municipal funds. There has not been sufficient appreciation of the importance of maintaining this type of ground water inventory on the part of State and municipal authorities. Two mimeographed memoranda have been prepared on the subject, one entitled "A nation-wide program of water-level measurements," and the other a preliminary report for the National Research Council on the "Water Resources Work of State Geological Surveys."—*A. W. Blohm.*

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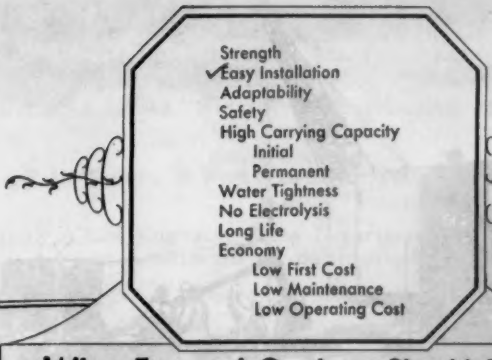

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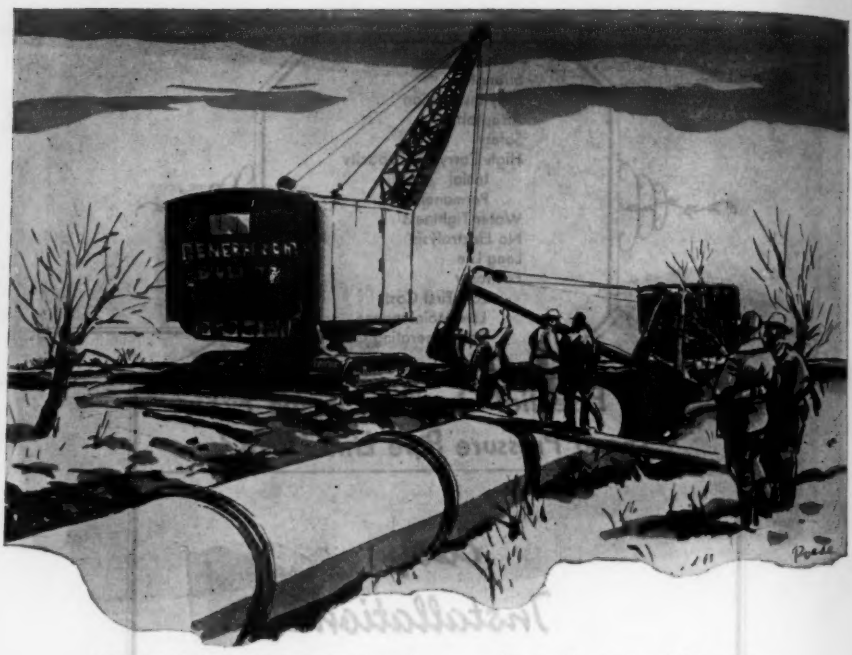

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December 29, 1936—New York Section—Hotel New Yorker, New York, N. Y. Secretary, R. K. Blanchard, Neptune Meter Co., 50 W. 50th St., New York, N. Y.

March 25–26, 1937—Four States Section—Philadelphia, Pa. Secretary, Carl A. Hechmer, Department Engineer, Washington Suburban Sanitary District, Hyattsville, Md.

March 30–April 1—Florida Section—Place to be announced later. Secretary, J. R. Hoy, 404 Hildebrandt Bldg., Jacksonville, Fla.

April 6–8—Southeastern Section—Place to be announced later. Secretary, W. H. Weir, State Board of Health, 135 State Capitol Bldg., Atlanta, Ga.

April 12–14—Kentucky-Tennessee Section—Hotel Patten, Chattanooga, Tenn. Secretary, H. D. Schmidt, Associate Director, Division of Sanitary Engineering, State Health Department, Nashville, Tenn.

April 14–16—Canadian Section—Hotel Windsor, Montreal, Canada. Secretary, A. E. Berry, Ontario Department of Health, Parliament Bldgs., Toronto, Ont., Canada.

April 19–22—Montana Section—Lewistown, Mont. Secretary, H. B. Foote, Director, Division of Water & Sewage, State Board of Health, Helena, Mont.

April 29–30—Illinois Section—Springfield, Ill. Secretary, W. D. Gerber, State Water Survey Division, Box 232, 57 Chemistry Bldg., Urbana, Ill.

May 20–22—Pacific Northwest Section—Place to be announced later. Secretary, Fred Merryfield, Assistant Professor of Civil Engineering, Oregon State College, Corvallis, Ore.

June 7–11—Annual Convention of American Water Works Association—Hotel Statler, Buffalo, N. Y. Secretary, Harry E. Jordan, 29 W. 39th St., New York, N. Y.

August 18–20 (tentative)—Central States Section—Dearborn, Mich. Secretary, H. Lloyd Nelson, U. S. Pipe & Foundry Co., 2122 Koppers Bldg., Pittsburgh, Pa.

October 11–14—Southwest Section—Austin, Tex. Secretary, L. A. Quigley, Superintendent, City Water Works, 3320 W. Berry St., Fort Worth, Tex.

October 20–23—California Section—Place to be announced later. Secretary, Carl M. Hoskinson, Chief Engineer, Division of Water, Sacramento, Calif.

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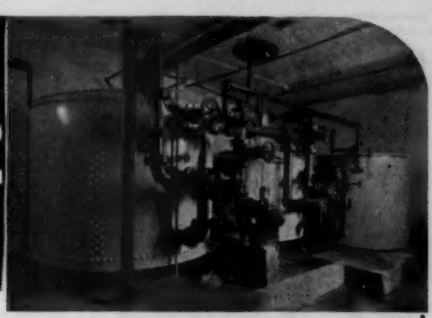

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For more than 30 years Golden-Anderson has been known as the manufacturer of the *World's Best automatic* valves.

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In the new Golden-Anderson Thru-Flow Valve the plug is unseated axially, rotated, and reseated axially, all in one free and frictionless operating movement and drop tight in either open or closed position; this is accomplished by means of a simple and sturdy patented toggle type rotor mechanism which is encased in a bath of oil in the operating head.

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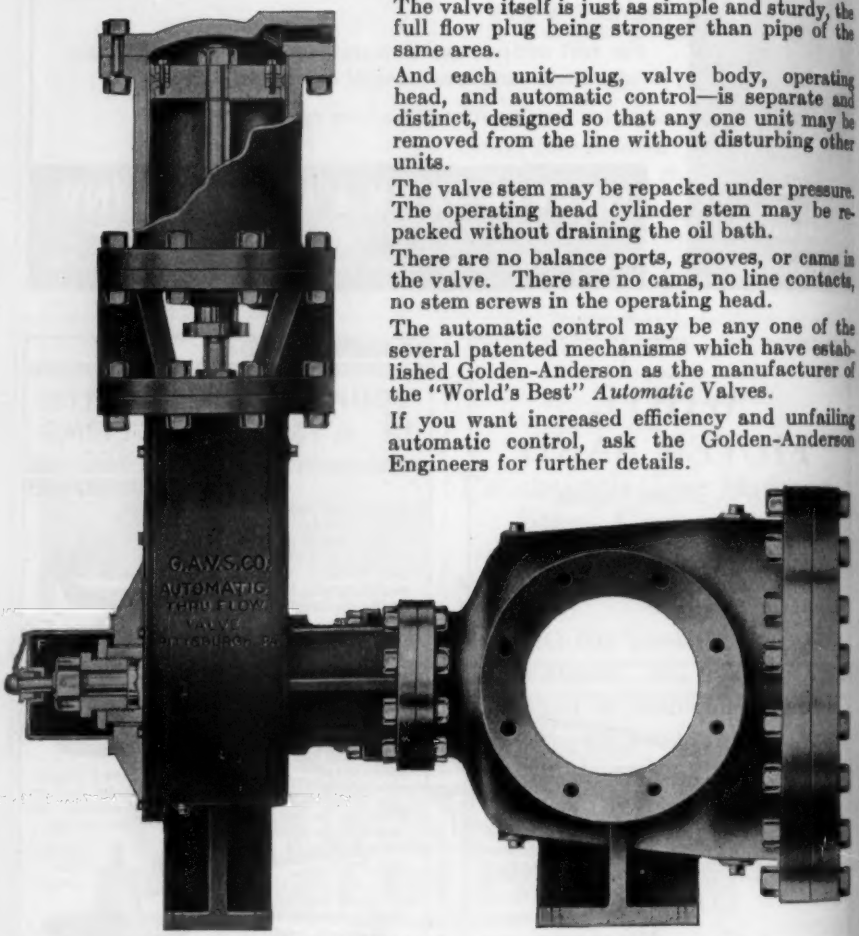
If you want increased efficiency and unfailing automatic control, ask the Golden-Anderson Engineers for further details.



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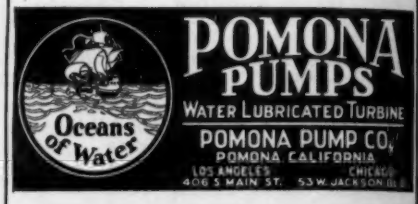

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● When you joint your Bell and Spigot Pipe with Tegul-MINERALEAD, the trench can be back-filled almost at once, for initial leakage will be cut as much as 90% ● Time will be saved—traffic hazards minimized ● Rain or flood won't hurt this ingot-form compound, nor will the contractor need to worry about change of composition en route to the job ● And your joints will hold fast under even the toughest conditions ● For more information, write The ATLAS MINERAL PRODUCTS Company of Penna., Mertatown, Pa.

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1. ***Easy to install*** ... Soft Anaconda Deoxidized Copper Tubes may be bent cold, by hand, around obstructions and corners.

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5. ***Ductility*** of soft Anaconda Deoxidized Copper Tubes reduces freezing hazard to a minimum.

6. ***Available*** ... Tubes and fittings are carried in stock by leading supply houses everywhere.

7. ***Identifiable*** ... by the Anaconda trademark—your assurance of quality—stamped in Anaconda Copper Tubes at close intervals throughout each length or coil.

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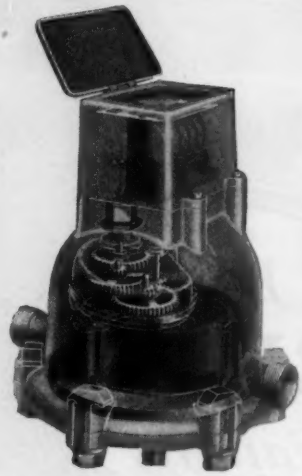
Convert Waste into Revenue!



Only a truly accurate meter will translate the smallest flow of water into a meter reading—convert waste into revenue.

Accuracy is assured in the Empire Water Meter, first, through the use of the oscillating piston principle of measurement, and, second, through those refinements in design and construction that have made this meter outstanding since 1884.

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Such performance justifies investigation. Some of the "reasons why" are contained in our Catalog 301. Write for it.

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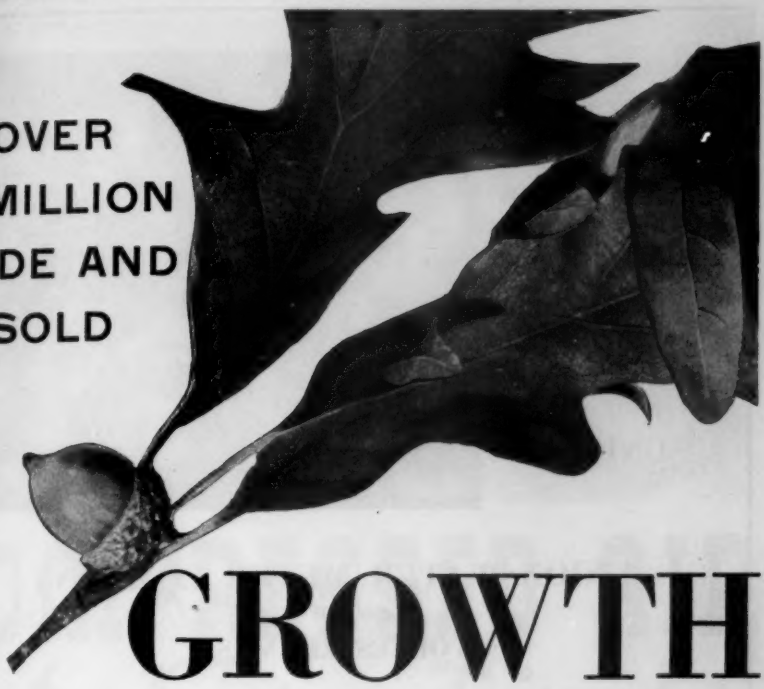

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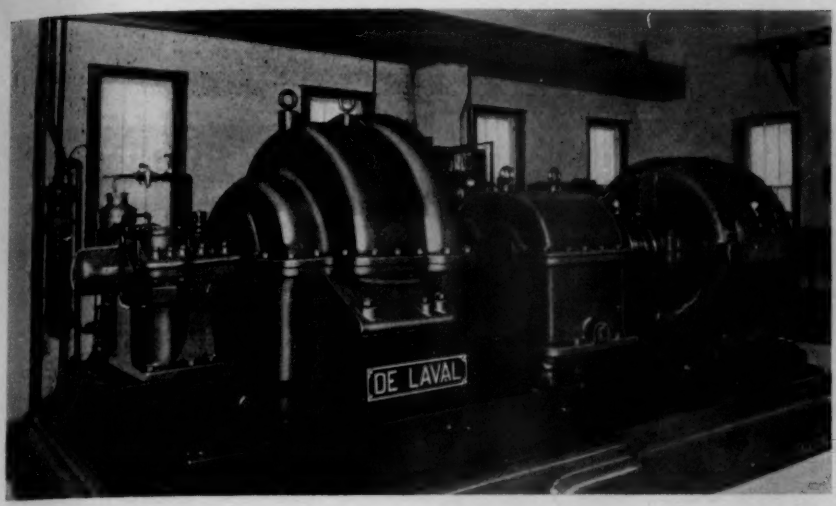

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Alco Electric Welded Steel Pipe is made in diameters ranging from 20" to 96" for either water supply or sewage disposal. Send for our illustrated bulletin, or have our engineers call to discuss your requirements.

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They are made suitable for use on Water, Gas, Steam Oil, etc., and are manufactured in all commercial sizes. We can furnish them with any style end connection; any style of gearing; any size Hydraulic Cylinder; and for Motor operation, to suit specifications.

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Corey
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- Non-freezing.
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- Rubber valves "Goodrich Quality."
- Interchangeable working parts.
- All working parts removable through top, avoiding necessity of digging up entire Hydrant when repairs are made (which is seldom).
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- Valve remains tightly closed should standpipe be broken off above ground (by accident). No flooding of ground around Hydrant.

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We have manufactured Coreys since 1896, and we believe they are the best Fire Hydrants on the market. Unless otherwise ordered, they are made suitable for a working pressure of 150 pounds per square inch, and each Hydrant is tested to 300 pounds per square inch. We can build them for greater working pressures if required.

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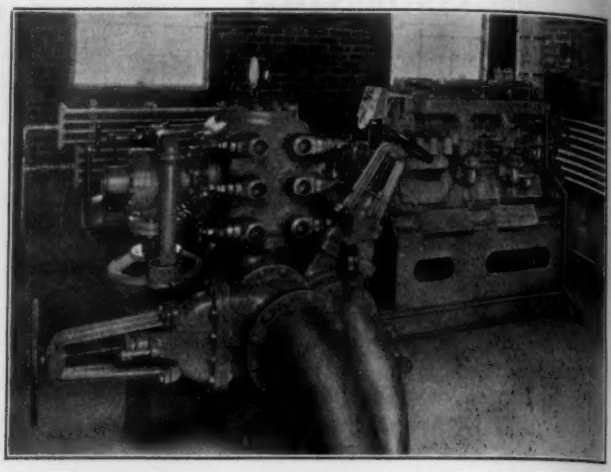
Spread the cost of a Sterling engine over the 20 to 30 years it is intended to serve! For an infinitesimally small amount annually, you can obtain the assurance that only a Sterling is built to provide.



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Easily installed. No frost protection necessary.

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End supports 24 feet apart. 100 lbs. pressure still in line and deflection of over 11 inches with joint still tight.

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LEAKY joints have a bearing on many of the problems which water company and water department officials are continually faced with. Unaccounted for water—excessive pumping charges—digging up costly pavements—even renewing pipe lines on account of lowered carrying capacity. Many of these worries can be avoided by making all new joints with Hydro-Tite.

Should a pipe line jointed with Hydro-Tite settle, as shown in the above picture, the joints will remain tight. Lines jointed with Hydro-Tite remain tight year after year and systems completely installed with Hydro-Tite joints are the tightest on record.

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A DEPENDABLE SELF - CAULKING JOINT COMPOUND

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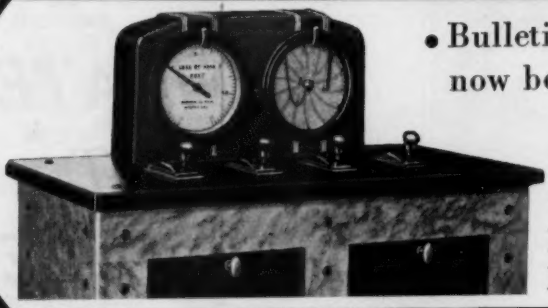

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First Quality Meters Exclusively

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WATER METERS
For Unrivalled Accuracy
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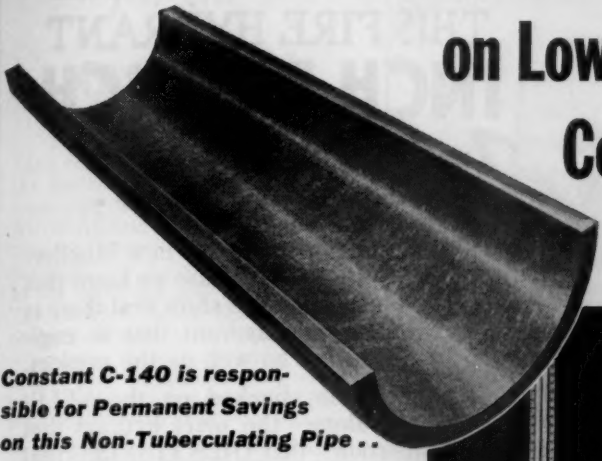
Here's the INSIDE STORY on Low Pumping Costs!



Constant C-140 is responsible for Permanent Savings on this Non-Tuberculating Pipe . .

ISN'T THIS TRUE? Since water pipe is laid solely for the purpose of carrying water, in the last analysis your investment is not in pipe but in water transportation facilities.

Why, then, in figuring the cost of a new main, should the yardstick be cost per foot of pipe? Isn't it much more logical to evaluate a water main primarily on its effectiveness as a water carrier?

And not solely on its effectiveness when new . . . all too often water mains are at the mercy of tuberculation, which constantly decreases the delivery capacity of ordinary pipe.

Hence, can you afford to pass up the savings in pumping costs offered by Transite Pipe, as already proved by hundreds of installations?

C-140 is the conservative minimum coefficient of Transite . . . not merely when first laid . . . not merely after five years or ten . . . but indefinitely.

1500' OF TRANSITE PIPE from a city main into an industrial plant were tested by The Pitometer Co., N. Y. C. Conclusion —"From a study of the data, we believe that an average coefficient of C-145 is very nearly correct for this pipe."

Made of asbestos and cement . . . and hence non-metallic . . . Transite Pipe cannot tuberculate. From the day it comes off the polished steel mandrel that forms its smooth interior wall, this pipe's all-important value of C stays unchanged. And thus pumping costs remain permanently low.

Send for a copy of our brochure, containing the complete story of Transite's important installation and maintenance savings as well as low pumping costs. Write to Johns-Manville, 22 East 40th Street, New York City.

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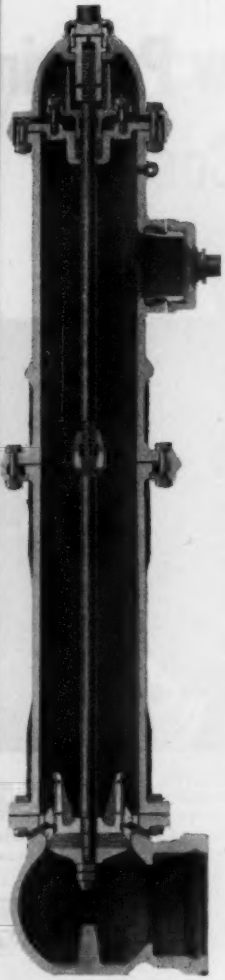
TRANSITE PRESSURE PIPE

An Asbestos Product

COMPARE
THIS FIRE HYDRANT
INCH BY INCH
To Any Other



We challenge comparison to this new Mueller-Columbian Fire Hydrant because we know that even a casual inspection will show that there is no comparison to this hydrant that is engineered for the future as well as the present.

Our case could be clinched on the SELF-OILING TOP alone—the *only* hydrant that needs no attention—that OILS ITSELF—that cannot bind—that operates easily in any kind of weather. But we know that you are also interested in the SAFETY-FLANGE feature of this hydrant—the feature that allows the hydrant to be repaired at a cost of about $5.00 and without any water shut-off if this hydrant should happen to be damaged by a traffic accident. And then there is the "business end" of the hydrant to be considered. Here in the Mueller-Columbian you will find the large main valve of compression type that prevents any flooding of streets. Bronze to bronze contact—no corrosion—no sticking—no leakage—long life chrome tanned leather—large double bronze bushed drain valves that are positively operated, insuring a dry barrel and eliminating any chance of freezing.

These are just a few points to compare. You can get the entire story from any Mueller man. Ask him for full details or write the nearest Mueller Co. office.

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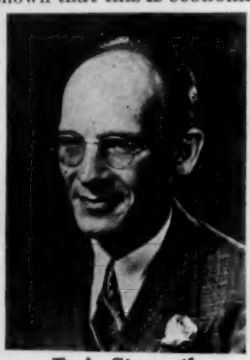
for the

NEW YEAR

For the past seven years we have endeavored to bring before the Members of the water works fraternity the message of AQUA NUCHAR and through its application the furnishing of a water that is palatable. In that period close to one thousand plants have used this product—some daily, others only intermittently, and then when faced with the severest taste and odor conditions. We feel convinced there is a dose of AQUA NUCHAR that will eliminate these tastes even under the worst conditions but in so doing, on the surface, the cost seems exceedingly high and has frequently been the means of not considering its application.

Our recommendation for the New Year is that consideration be given to the daily application of AQUA NUCHAR in small dosages, so that the Plant will be properly seeded and a gradual improvement in the water so that when severe tastes and odors are encountered in the raw water supply all that is necessary is to step up the dose to a point sufficiently large to eliminate these tastes. Actual experience has shown that this is economical and from a survey made of a number of plants—and using the per capita consumption of 100 gallons daily, it is estimated that the per capita cost of furnishing palatable drinking water using AQUA NUCHAR is slightly over 3¢ per year.



E. A. Sigworth
Technical Sales Staff

During the past seven years, since AQUA NUCHAR has been introduced, we realize fully that it was during a period when many of the Municipalities have been pressed for funds and all economical measures adopted to keep within the budget requirements. This period is gradually passing and more funds are available. We feel now is the time for the furnishing of a palatable water, since you are already furnishing one that is safe.

You have noted from the daily press the rising prices in practically all commodities and we know that you will be pleased to learn that AQUA NUCHAR will be available for the calendar year 1937 at prices no higher than have prevailed in the past.

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230 Park Avenue
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205 West Wacker Drive
Chicago, Ill.

418 Schofield Bldg.
Cleveland, Ohio

Help Build up Your Association by Bringing in a New Member

SEND FOR APPLICATION BLANKS

AMERICAN WATER WORKS ASSOCIATION

29 WEST 39TH STREET
NEW YORK CITY

Full main pressure at the hydrant nozzles

EVERY part of a Kennedy SAFETOP Fire Hydrant is designed to insure minimum pressure loss from water main to nozzle inlet. For example:

Area of standpipes is 200% to 300% of inlet valve areas.

Inlet valve ports have larger diameter than each nominal hydrant size.

Inlet elbows and nozzles are proportioned with easy curves.

There are no sharp corners or pockets where eddies might form.

Interior of standpipe, inlet elbows and nozzles are carefully examined during assembly to make sure that all water passages are perfectly smooth.

Moreover, the Safety Breakable Section which protects the major and expensive parts of the hydrant from damage in case of a smashing collision does not interfere in any way with the normal functioning of the hydrant. Both the standpipe and stem are fully as strong and rigid as any one-piece hydrant, and the simple straight-line operating mechanism works freely and positively at all times.

Fire chiefs are as enthusiastic about the easy operation and dependable service of the SAFETOP Fire Hydrant as are water department superintendents concerning its unique safety and economy features. Kennedy SAFETOPS are a double protection to the community—in fire service and in collision emergencies.

The Kennedy Valve Mfg. Co.
Elmira, N. Y.

Write for Bulletins

KENNEDY

SAFETOP FIRE HYDRANT

REG. U.S. PAT. OFF.

STANDARD METHODS FOR THE EXAMINATION OF WATER AND SEWAGE

EIGHTH EDITION

Public health workers and water works operators have bought 2100 copies of the Eighth Edition of this classic in four months.

That many people can't be wrong!

Perhaps the book is in demand because the fact is generally known that it has been completely rewritten and revised. Perhaps the knowledge that certain important undertakings in progress for some time were finally culminated and the results incorporated in the joint report has something to do with its popularity. Certainly it is the only publication of its kind and a definitely required item in the library of every person concerned with operation of water works and control of water supplies.

Standard Methods continues to be popular and is still available at $2.50 per copy.

THE AMERICAN PUBLIC HEALTH ASSOCIATION
50 West 50th Street **New York, N. Y.**

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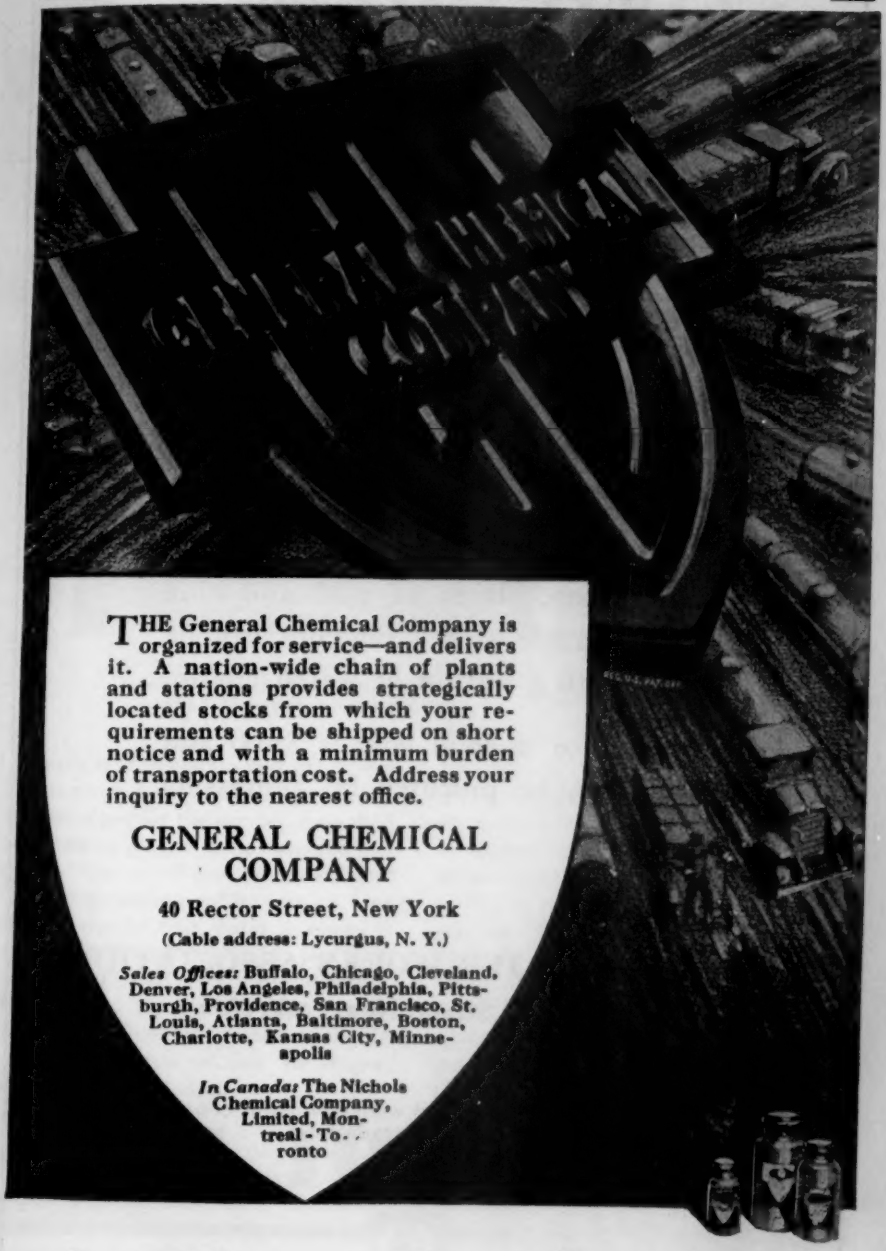

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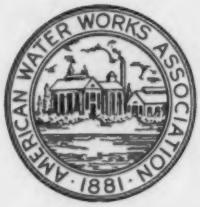
In Canada: The Nichols Chemical Company, Limited, Montreal - Toronto

for Water Purification

BADGE THE AMERICAN WATER WORKS ASSOCIATION



This cut is a facsimile, enlarged, of the official badge or emblem of the association. It is of gold and blue enamel made with a pin, but can be made into a button or watch charm.

The price in solid gold is $5.00 and they can be procured by addressing

AMERICAN WATER WORKS ASSOCIATION
29 West 39th Street, New York, N. Y.

These badges are not to be confused with the usual convention badge, but are for everyday use

Delivering Water night and day for 106 years!

Unretouched photograph of a section of 106-year-old cast iron water main still rendering satisfactory service in Philadelphia's distribution system.

The following tabulation shows the percentage of cast iron pipe used in the water distribution systems of the 15 largest cities in the United States as reported in 1935 by their Water Departments.

CITY	PERCENTAGE
New York	97.2
Chicago	100.0
Philadelphia	98.3
Detroit	98.7
Los Angeles	74.0
Cleveland	98.9
St. Louis	98.7
Baltimore	99.7
Boston	99.8
Pittsburgh	97.9
San Francisco	76.8
Milwaukee	100.0
Buffalo	99.8
Washington D.C.	98.8
Minneapolis	95.8

Water is free if you go and get it. But if you want it at the turn of a faucet you must pay for the service. Less than the price of a soda for a hundred gallons—a very small cost for an efficient and indispensable public service. One of the reasons why water is cheap is the long life and negligible maintenance cost of cast iron water distribution mains. More than 95% of the pipe which distributes water to the 24 million residents of our 15 largest cities is cast iron pipe.

Cast iron is the standard material for water mains. Its useful life is *more than a century* because of its effective resistance to rust. It is the one ferrous metal pipe for water and gas mains, and for sewer construction, that will not disintegrate from rust. Available in diameters from 1¼ to 84 inches. For further information, address The Cast Iron Pipe Research Association, Thos. F. Wolfe, Research Engineer, 1013 Peoples Gas Building, Chicago, Illinois.

CAST IRON PIPE

Methods of evaluating bids now in use by engineers *rate the useful life of cast iron pipe at 100 years*

IMPORTANT

THE Association has run short of certain numbers of the Journal. Any members who do not desire to preserve their copies of the following issues and are willing to return same, will be acting to the benefit of the Association.

AMERICAN WATER WORKS ASSN.,
29 W. 39th St., New York, N. Y.

April	**1936**
January and March,	1920
January and March,	1922
January, March, May, July, and September,	1924
All issues for	1926
January, February, March and April,	1929
January, February, March, April and May,	1930

A Branch Connection While the Water Flows

QUICKLY, easily, safely, a 30" branch connection can be cut into a 30" or larger main by the use of a Smith Tapping Machine while the water in the main flows merrily along under its usual full head of pressure.

Shut-downs are avoided. They are unnecessary. Expense is saved. Danger is avoided. Health is protected.

This machine is power-operated. It uses an air-motor which supplies a smooth, steady flow of power which enables it to cut through the hardest main in less than an hour.

Other sizes of Smith Tapping Machines will make branch connections from 2" to 42" into any size mains not smaller in diameter than the connection desired.

Smith Tapping Machines are standard equipment today in the water and gas fields.

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THE A. P. SMITH MFG. CO. EAST ORANGE, N. J.

WITH CHRISTMAS COMES THE TIME WHEN THOUGHTS TURN FROM THE ROUTINE OF DAILY BUSINESS LIFE. MAY WE ALL THEREFORE JOIN IN WISHING YOU HAPPINESS—PROSPERITY AND GOOD HEALTH DURING THE HOLIDAY SEASON AND THE NEW YEAR

Activated Alum Corp.

— OFFICE —	— WORKS —
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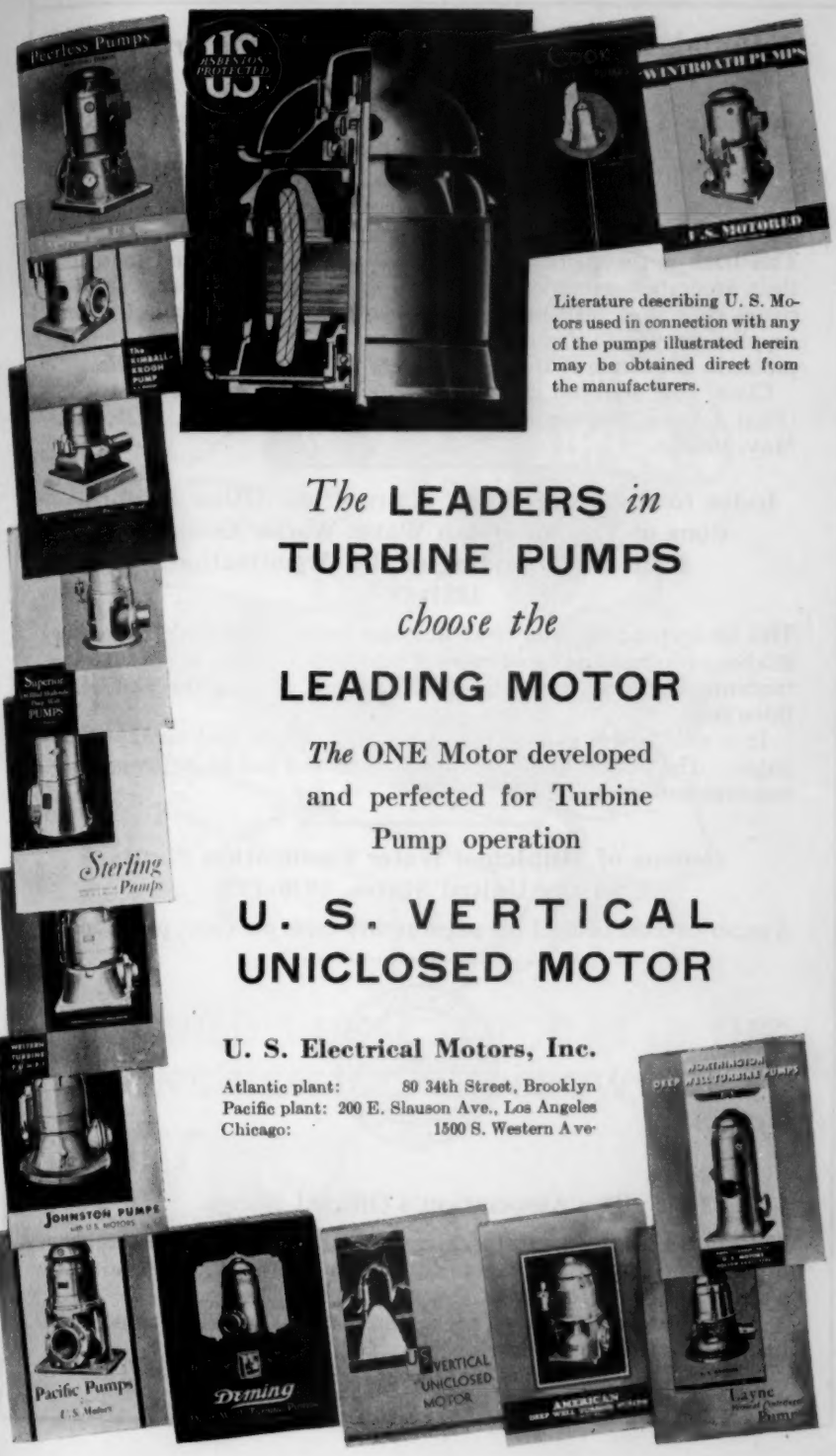

Literature describing U. S. Motors used in connection with any of the pumps illustrated herein may be obtained direct from the manufacturers.

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Manual of Water Works Practice

This book is the coördinated effort of 300 specialists and presents their accurate summaries of modern water works practice. It discusses collection, distribution, treatment and consumption of water supplies, contains accepted specifications, and treats of water supply problems in relation to the health, safety and welfare of the public.

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Index to the Proceedings, Journal and Other Publications of The American Water Works Association from the Founding of the Organization. 1881–1933

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It is well bound in buckram, with stiff covers, and contains 233 pages. The price is $1.50 per copy to members and $2.50 per copy to non-members, postpaid.

Census of Municipal Water Purification Plants in the United States, 1930–1931

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The Association's Official Badge

This cut is a facsimile, greatly enlarged, of the official badge or emblem of the Association. It is of gold and blue enamel and can be made into a pin, button or watch charm.

These badges are not to be confused with the usual convention badge, but are for everyday use.

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Soft water makes every housewife's work easier—saves soap—makes scrubbing, cleaning, laundering and dishwashing more effective and less laborious—reduces wear and tear suffered by garments and linens in washing. Velvety soft water is delightful for bathing—safeguards skin and complexion from hard water hazards—is a wonderful improvement over hard water for shaving and shampooing—makes foamy, fluffy suds with less soap—leaves no "ring" around bath-tub or basin—and prevents costly stoppage of plumbing by accumulations of scale and lime-soap curd which hard water causes. Soft water is better for cooking, better for cleaning, better for the health and comfort of every member of the family.

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Permutit

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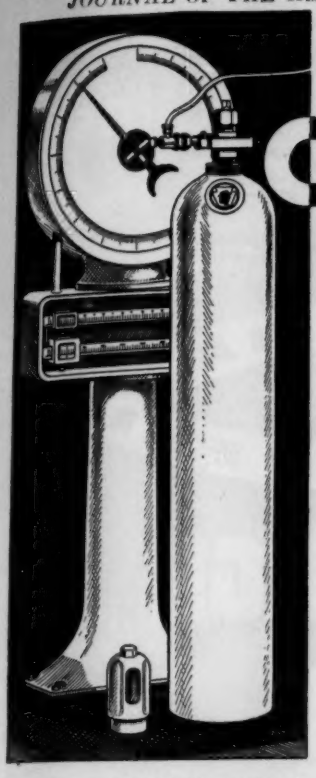

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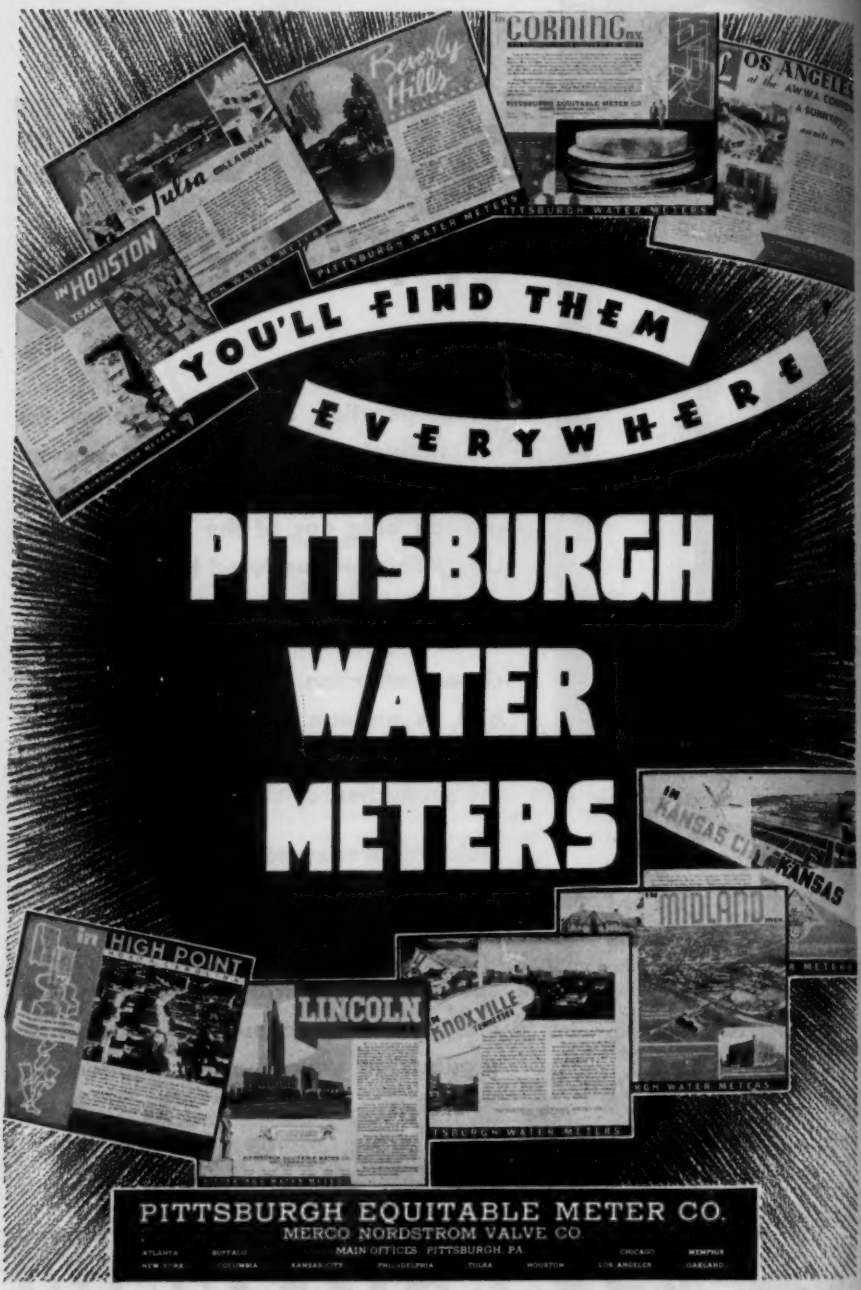

PITTSBURGH WATER METERS

SEP 21 1936

SUPPLEMENT TO

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

VOL. 28 SEPTEMBER, 1936 NO. 9

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AMERICAN WATER WORKS ASSOCIATION
29 W. 39th St., New York, N. Y.